STUK-B 222 / MAY 2018

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Implementing nuclear non-proliferation in Finland

Regulatory control, international cooperation and the Comprehensive Nuclear-Test-Ban Treaty

Annual report 2017

Olli Okko (ed)

Säteilyturvakeskus
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STUK • **SÄTEILYTURVAKESKUS**
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ISBN 978-952-309-419-2 (print) Erweko Oy, Helsinki 2018
ISBN 978-952-309-420-8 (pdf)
ISSN 0781-1713

OKKO Olli (ed). Implementing nuclear non-proliferation in Finland. Regulatory control, international cooperation and the Comprehensive Nuclear-Test-Ban Treaty. Annual report 2017. STUK-B 222. Helsinki 2018. 41 pp. + Appendices 5 pp.

Keywords: nuclear safeguards, regulatory control, comprehensive nuclear-test-ban treaty, verification

Abstract

The regulatory control of nuclear materials (nuclear safeguards) is a prerequisite for the peaceful use of nuclear energy in Finland. In order to maintain the Finnish part of the international agreements on nuclear non-proliferation – mainly the Non-Proliferation Treaty (NPT) – this regulatory control is implemented by the Nuclear Materials Section of the Finnish Radiation and Nuclear Safety Authority (STUK).

Finland has quite significant nuclear power production, but the related nuclear industry is rather limited. Most of the declared nuclear materials (uranium, plutonium and thorium) in Finland reside at the nuclear power plants in Olkiluoto and Loviisa. Additionally, there is the closed research reactor in Espoo with nuclear fuel at the site, as well as a dozen minor nuclear material holders in Finland. The International Atomic Energy Agency (IAEA) and the European Commission made their visits to the construction site of the Olkiluoto 3 unit and installed safeguards instrumentation before the first fuel delivery that took place in 2017.

STUK maintains a national nuclear materials accountancy system and verifies that nuclear activities in Finland are carried out in accordance with the Finnish Nuclear Energy Act and Decree, European Union Safeguards Regulation and international agreements. These tasks are performed to verify that Finland can assure itself and the international community of the absence of undeclared nuclear activities and materials. In addition to this, the IAEA evaluates the success of the state safeguards system, and the European Commission participates in safeguarding the materials under its jurisdiction.

The results of STUK's nuclear safeguards inspection activities in 2017 continued to demonstrate that Finnish licence holders take good care of their nuclear materials. There were no indications of undeclared nuclear materials or activities and the inspected materials and activities were in accordance with the stakeholders' declarations.

The number of the routine inspection days of the international inspectorates has been reduced significantly due to the state-level safeguards approach for Finland, which has been in force since 2008. The number of international inspection days per year is approximately 25. Neither the IAEA nor the Commission made any remarks nor did they present any required actions based on their inspections during 2017. By means of their nuclear materials accountancy and control systems, the stakeholders enabled STUK to fulfil its own obligations under the international agreements relevant to nuclear safeguards. In safeguards, STUK continues with 40 annual inspections and 60 inspection days.

A major goal of all current Comprehensive Nuclear-Test-Ban Treaty (CTBT) related activities is the entry into force of the CTBT itself. An important prerequisite for such positive political action is that the verification system of the Comprehensive Nuclear-

Test-Ban Treaty Organization (CTBTO) is functioning and able to provide assurance to all parties that it is impossible to make a clandestine nuclear test without detection. The FiNDC is committed to its own role in the common endeavour, so that the verification system of the CTBTO can accomplish its detection task as demonstrated once during 2017.

The human resources development at the Nuclear Materials Section during 2017 was focused on nuclear material control: in particular, standard operational procedures were addressed within the nuclear regulator departments. At the Nuclear Materials Section, the new nuclear materials database was developed in this context. Due to the need to regulate the construction of the disposal facility for spent nuclear fuel at the Olkiluoto repository site, safeguards instrumentation was under development, in particular the passive gamma emission tomography for the verification of spent fuel.

In addition, STUK contributed to educational workshops and training courses for authorities who represent nuclear newcomers: countries that aim at uranium production or nuclear power in cooperation with the IAEA. STUK also contributed to EU-funded projects in Tanzania and Vietnam, respectively. In 2017, the partnerships programme between King Abdullah City for Atomic and Renewable Energy (K.A.CARE), Kingdom of Saudi Arabia, and STUK continued supporting the establishment of the Saudi Arabia's regulatory authority in relation to its nuclear energy programme.

Preface

Every year, STUK prepares the report on Implementing Nuclear Non-Proliferation in Finland. The main task of the report is to inform and share experiences with colleagues and interested parties on safeguards implementation.

The report was restructured in 2016–2017 to correspond the reader survey of 2016. In this new setting, Chapter 2 is shortened but kept in order to present the Finnish system and the relevant stakeholders to new readers in a concise way. Chapter 3 is presents the safeguards activities immediately after the introductory part, and development work and other activities are dealt with later in the report. STUK's activities with the Comprehensive Nuclear-Test-Ban Treaty and nuclear disarmament are included in report.

The report was compiled by the staff member of the Safeguards Section of STUK. The inspectors in the office have specific oversight tasks and duties towards individual operators and stakeholders, so all staff members contribute to the reporting. The responsible officers for nuclear material holders are Henri Niittymäki for Loviisa NPP, Timo Ansaranta for Olkiluoto NPP, Tapani Honkamaa for the new Olkiluoto 3 unit, Mikael Moring and Olli Okko for the encapsulation plant and geological repository in Olkiluoto, Marko Hämäläinen for the Hanhikivi project, Henri Niittymäki and Olli Okko for the Technical Research Centre of Finland, and Timo Ansaranta and Henri Niittymäki for minor holders. There are deputy arrangements in place in order to ensure instant duplicate knowledge. Not all the necessary actions and responsibilities, such as licensing and approvals, are covered in this list of facility-specific tasks.

In addition, there are several additional tasks, which the Support Programme to the IAEA contributes to the international safeguards R&D work. Mr Honkamaa acts as support programme coordinator and prepares its annual report and the highlights in this report. Mr Moring is responsible for the Finnish National Data Centre to the CTBTO and, of STUK's other departments, Kari Peräjärvi contributes to GICNT and IPNDV activities included in this report. At the end of 2017 the domestic non-proliferation co-operation between ministries and STUK was strengthened by nominating Elina Martikka to continue as International Cooperation Manager, while Marko Hämäläinen took over the Safeguards Section as the section head. In the end of the year the assistant Ritva Kylmälä, who took care of the supporting activities of the inspections and other activities in the Section, retired. The contents of this annual report can be expected to the reflect these changes in future. Comments and suggestions are welcome to improve the content and normativity of the report.

The Editor

Contents

1 Implementation of nuclear non-proliferation in Finland

The regulatory control of nuclear materials, nuclear safeguards, is a prerequisite for the peaceful use of nuclear energy in Finland. In order for Finland to have a nuclear industry, most of which consists of nuclear energy production, it must be ensured that nuclear materials, equipment and technology are used only for their declared peaceful purposes. The basis of nuclear safeguards is the national system for the regulatory control of nuclear materials and activities. Nuclear safeguards represent an integral part of nuclear safety and nuclear security and are applied to both large- and medium-sized nuclear industry and to small-scale nuclear material activities. Along with the safeguards, the regulatory process for nuclear non-proliferation includes transport control, export control, border control, international cooperation, and monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

Safeguards are applied to nuclear materials and activities that can lead to the proliferation of nuclear weapons. These safeguards include nuclear materials accountancy, control, security and the reporting of nuclear fuel cycle-related activities. The main parties involved in a state nuclear safeguards system are the facilities that use nuclear materials, often referred to as “licence holders” or “operators” and the state authority, STUK. A licence holder shall take good care of its nuclear materials and the state authority shall provide the regulatory control to ensure that the licence holder fulfils the requirements. The control of nuclear expert organisations, technology holders and suppliers, to ensure the non-proliferation of sensitive technology, is also a growing global challenge for all stakeholders. In Finnish legislation, all these stakeholders are dealt with as users of nuclear energy.

Finland has quite significant nuclear power production, but the related nuclear industry is rather limited. Most of the declared nuclear materials (uranium, plutonium and thorium) in Finland reside at the nuclear power plants at Olkiluoto and Loviisa. Additionally, there is the research reactor in Espoo with nuclear materials, as well as a dozen minor nuclear material holders in Finland. Most of the applied nuclear research and development activities are carried out to improve the maintenance and safety of the nuclear power plants.

1.1 International safeguards agreements and national legislation

Nuclear safeguards are based on international agreements, the most important and extensive of which is the Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT). The Treaty Establishing the European Atomic Energy Community (Euratom Treaty) is the basis for the nuclear safeguards system of the European Union (EU). Finland is bound by both these treaties, and also has several bilateral agreements in the area of the peaceful use of nuclear energy. When Finland joined the EU, the bilateral agreements with Australia, Canada and the USA were partly substituted with the corresponding Euratom agreements (see Appendix 3 for the relevant legislation).

One new agreement on cooperation in peaceful uses of nuclear energy for Finland entered into force in 2017. The agreement on cooperation in scientific and applied research, exchange of scientific and technological information, transfer of nuclear material, non-nuclear material, equipment and technology as well as the provision of relevant technological consultancy and services was signed with the Kingdom of Saudi Arabia in 2015. This agreement was ratified on 3 June 2017.

Finland was the first state where an INFCIRC[1]/153-type comprehensive Safeguards Agreement with the IAEA entered into force (INFCIRC/155, 9 February 1972). When Finland joined the EU (1 January 1995), this agreement was suspended and subsequently the Safeguards Agreement between the non-nuclear weapon Member States of the EU, the Euratom and the IAEA (INFCIRC/193) entered into force in Finland on 1 October 1995. Finland signed the Additional Protocol (AP) to the INFCIRC/193 in Vienna on 22 September 1998 with the other EU Member States and ratified it on 8 August 2000. The Additional Protocol entered into force on 30 April 2004, once all the EU Member States had ratified it. The scope and mandate for Euratom safeguards are defined in the European Commission Regulation No. 302/2005.

After Finland joined the EU as a Member State and thereby subjected itself to the Euratom safeguards, a comprehensive national safeguards system was still maintained and further developed. The basic motivation for this is the responsibility assumed by Finland for its safeguards and security under the obligations of the NPT, and also to ensure fulfilment of the Euratom requirements.

The national safeguards derive their mandate and scope from the Finnish Nuclear Energy Act and Decree. The operator's obligation to have a nuclear material accountancy system and the right of STUK to oversee the planning and generation of design information for new facilities was introduced from STUK requirements into the Nuclear Energy Decree.

In 2015, the Nuclear Energy Act was amended in such a way that the Government Decrees on nuclear safety, nuclear waste management, emergency preparedness and nuclear security were replaced by new STUK Regulations. Some general features were introduced from the old Government Decrees into the Nuclear Energy Decree, but most of the detailed requirements were included in the new STUK Regulations that entered into force on 1 January 2016 parallel to the amendment of the Nuclear Energy Decree.

As stipulated by the Act, STUK issues detailed requirements (the YVL Guides) on safety, security and safeguards that apply to the use of nuclear energy. STUK's safeguards requirements for all users of nuclear energy during all phases of the nuclear fuel cycle are set in YVL Guide D.1 Regulatory Control of Nuclear Safeguards. Areas covered in the new comprehensive guide include the obligations and measures stemming from the Additional Protocol for the Safeguards Agreement and from recent developments. All stakeholders must describe their own safeguards system in written form (as a nuclear materials handbook or safeguards manual), in order to ease their task of fulfilling their obligations and to guarantee the effective and comprehensive operation of the national safeguards system. In the new guide, there are also specific national requirements for the disposal of spent nuclear fuel in a geological repository. In general, nuclear safeguards control applies to:

- nuclear material (special fissionable material and source material)
- nuclear dual-use items (non-nuclear materials, components, equipment and technology suitable for producing nuclear energy or nuclear weapons as specified in INFCIRC/254, Part 1)
- licence holders' activities, expertise, preparedness and competence including information security
- R&D and other activities related to the nuclear fuel cycle as defined in the Additional Protocol
- design and construction of new nuclear facilities.

1.2 Parties of the Finnish safeguards system

The main parties involved in the Finnish safeguards system are the authorities and stakeholders. Undistributed responsibility for the safety, security and safeguards of the use of nuclear energy rests with the stakeholder. It is the responsibility of STUK as the state regulatory authority to ensure that the licence holders and all other stakeholders in the nuclear field comply with the requirements of the law and the nuclear safeguards agreements. To complement the national effort, international control is necessary in order to demonstrate credibility and the proper functioning of the national safeguards system.

[1] INFCIRC = IAEA Information Circulars

1.2.1 Ministries

The Ministry for Foreign Affairs (MFA) is responsible for national non-proliferation policy and international agreements. The MFA is responsible for the export control of nuclear materials and other nuclear dual-use items, including sensitive nuclear technology. The Ministry of Economic Affairs and Employment (MEAE) is responsible for the supreme command and control of nuclear matters. MEAE is responsible for the legislation related to nuclear energy and is also the competent authority mentioned in the Euratom Treaty. Other ministries, such as the Ministry of the Interior and the Ministry of Defence, also contribute to the efficient functioning of the national nuclear safeguards system.

1.2.2 STUK

As per the Finnish nuclear legislation, STUK is responsible for maintaining the national nuclear safeguards system in order to prevent the proliferation of nuclear weapons. STUK regulates the stakeholders' activities and ensures that the obligations of international agreements concerning the peaceful use of nuclear materials are met. Regulatory control by STUK includes the possession, use, production, transfer (national and international), handling, storage, transport, export and import of nuclear materials and nuclear dual-use items. STUK is in charge of Finland's approval and consultation process for inspectors from the IAEA and the European Commission.

Nuclear safeguards by the Nuclear Materials Section of STUK cover all typical measures of a State System of Accounting for and Control of Nuclear Materials (SSAC), together with many other activities. STUK reviews the stakeholders' reports (operational notifications, inventory reports), inspects their accountancy, facilities and transport arrangements on site, and performs system audits. STUK runs a verification programme for nuclear activities to assess the completeness and correctness of the declarations by the licence holders. STUK acts proactively in order to avoid or solve in advance any foreseeable questions to be raised by the international inspectorates. Nuclear safeguards on the national level are closely linked to other functions of nuclear materials control and non-proliferation: licensing, export control, border control, transport control, combating illicit trafficking, physical protection of nuclear materials, monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT), and also Global Initiative to Combat Nuclear Terrorism (GICNT). Nuclear safety and particularly nuclear security objectives are closely complemented by safeguards objectives. For this reason, the research and regulatory units in the fields of safety, security and safeguards at STUK cooperate under the non-proliferation framework. The scope of non-proliferation work is linked to many organisational units of STUK (Fig. 1).

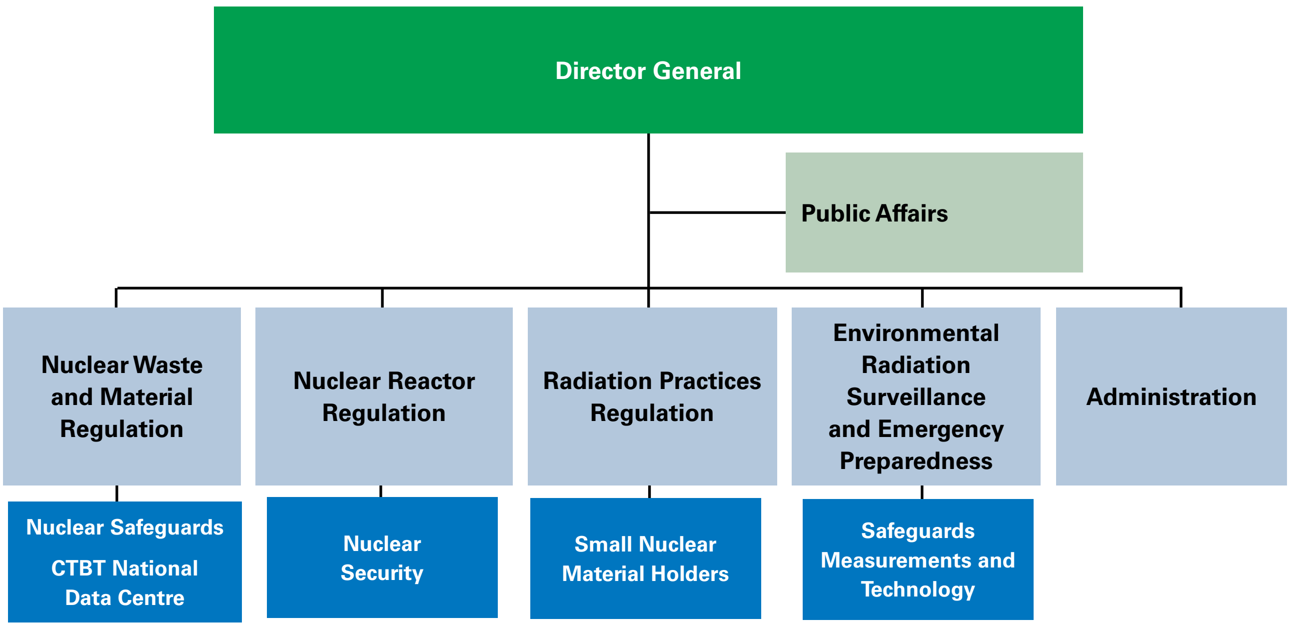


Figure 1. Framework to implement nuclear non-proliferation within STUK's organisation.

The distribution of the working days of the Nuclear Materials Safeguards Section in the different duty areas is presented in Figure 2. Most of the working days are invoiced to the stakeholders. As seen in Figure 2, the duty areas are divided into those of direct oversight and inspections (basic operations), support functions including maintenance, development work for the regulatory functions and consultancy, including international cooperation financed by the Ministry for Foreign Affairs or the European Union. The state budgetary funding constitutes only about 5% of the total funding of the Nuclear Materials Safeguards Section.

Nuclear non-proliferation is, by its nature, an international domain. STUK therefore actively participates in international nuclear safeguards-related cooperation and development efforts, and also participates in the European Safeguards Research and Development Association's ESARDA's working groups, executive board and the steering committee. The practices obtained at the current nuclear construction projects have emphasised the need to bring in the safeguards requirements at an early stage of facility design. The experience has been shared with the IAEA, several international fora and also in bilateral cooperation with several countries.

1.2.3 Licence holders and other users of nuclear energy

The essential parts of the national safeguards system are the licence holders and other users of nuclear energy – in nuclear terminology, often called the operators and other stakeholders. In the Finnish legislation, the term 'use of nuclear energy' comprises a wide range of nuclear-related activities, such as those defined in the Addition Protocol. These stakeholders, in particular the licence holders, perform key functions in the national safeguards system: control of the authentic source data of their nuclear materials in addition to accountancy for nuclear materials at the facility level for each of their material balance areas (MBA). Each licence holder or other user of nuclear energy must operate its safeguards system in accordance with its own nuclear materials handbook or safeguards manual. The requirements of the Additional Protocol are integrated in the handbook to facilitate implementation of safeguards at the site, including the material balance areas. Other stakeholders too, as users of nuclear energy, are requested to have a safeguards manual to facilitate safeguards implementation. The nuclear materials handbook or safeguards manual is part of the operator's quality system and is reviewed and approved by STUK.

In Finland, there are about 30 stakeholders responsible for nuclear material accountancy and control. The major material balance areas are list-

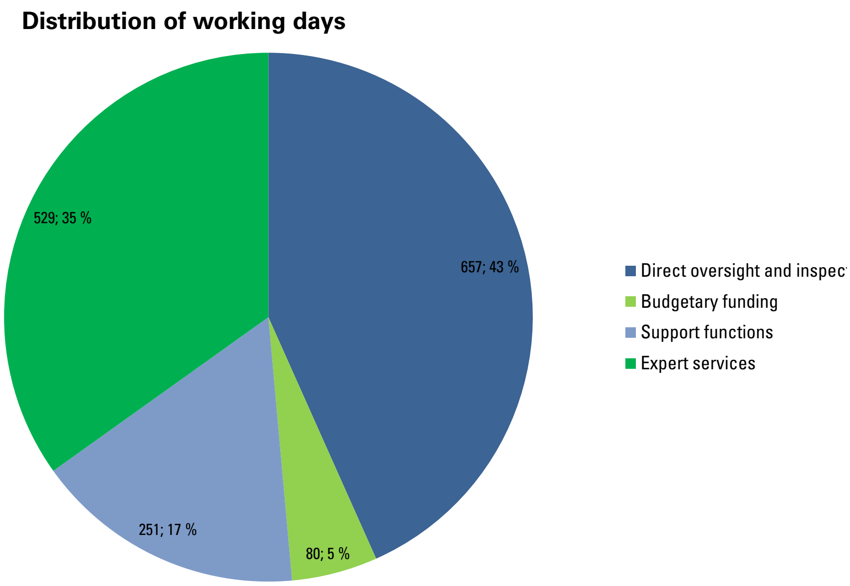


Figure 2. The distribution of working days of the Nuclear Materials Section in the various duty areas.

Table 1. Status of regulatory documents for material balance areas in Finland at the end of 2017.

MBA, location	BTC, last upd.	Site (AP), founded	PSP, in force	FA, in force	Licence/DiP, in force (from/until)	SG Manual, approved
WLOV, Loviisa	15.5.2017	S SF LOV1, 8.7.2004	Yes, 4.5.1998	No	Operating, LO1 until 31.12.2027 LO2 until 31.12.2030	Yes, 30.11.2012
WOL1, Olkiluoto	12.3.2016	S SF OLK1, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2018	17.11.2016
WOL2, Olkiluoto	12.3.2016	S SF OLK1, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2018	17.11.2016
WOLS, Olkiluoto	12.3.2016	S SF OLK1, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2018	17.11.2016
WOL3, Olkiluoto	31.3.2016	S SF OLK1, 8.7.2004	No	No	Construction, granted 17.2.2005	17.11.2016
WOLE, Olkiluoto	19.5.2017	S SF POS1, 31.3.2010	No	No	Construction, 12.11.2015	No, included in WOLF manual
WOLF, Olkiluoto	13.12.2017	S SF POS1, 31.3.2010	No	No	Construction, 12.11.2015	9.6.2017
WFV1, Pyhäjoki	3.2.2017	No	No	No	DiP, 1.7.2010	4.7.2014
WRRF, Espoo	31.12.2014	S SF VTT1, 8.7.2004	Yes, 9.7.1998	No	Operating, until 31.12.2023	12.4.2017
WNSC, Espoo	12.5.2017	Included 2017 to SSF VTT1	No	No	Operating, until 31.12.2026	14.11.2016
WFRS, Helsinki	1.3.2017	S SF STUK, 8.7.2004	No	No	Not required (as an authority)	17.2.2017
WHEL, Helsinki	21.12.2016	S SF HYRL, 8.7.2004	No	No	Operating, until 31.12.2027	3.7.2017
WKKO, Kokkola	30.5.2013	No	No	No	Operating, until 31.12.2024	18.6.2015
WNNH, Harjavalta	30.1.2017	No	No	No	Operating, until 31.12.2019	18.6.2015
WTAL, Talvivaara	14.9.2017	No	No	No	Operating (pilot test) until 30.6.2023	6.11.2017
WDPJ, Jyväskylä	10.3.2017	No	No	No	Operating, until 31.12.2024	2.5.2017

Finnish material balance areas and their status as 31.12.2017. MBA (material balance area code), BTC (Basic Technical Characteristics, i.e. Design Information), AP (the Additional Protocol), PSP (Particular Safeguards Provisions set by the European Commission), FA (Facility Attachment prepared by the IAEA), DiP (Decision-in-Principle, date of Parliament approval, in force 5 years).

ed in Table 1 and described more in detail below. Most of all nuclear materials in Finland reside at the nuclear power plants at Loviisa and Olkiluoto. The amounts of nuclear materials (uranium, plutonium) in Finland in 1990–2017 are presented in Figures 3 and 4. Currently there are six sites in the sense of the Additional Protocol: the two nuclear power plant sites, the geological repository site in Olkiluoto, and three minor sites: the Technical Research Centre of Finland, the Radiation and Nuclear Safety Authority and the Laboratory of Radiochemistry at the University of Helsinki.

With the basic technical characteristics (BTC) submitted by a licence holder or by other stakeholder as groundwork, the European Commission adopts particular safeguards provisions (PSP) for that licence holder. PSPs are drawn taking operational and technical constraints into account in close consultation with both the person or undertaking concerned and the relevant member state. Until PSPs are adopted, the person or undertaking shall apply the general provisions of the Commission regulation No 302/2005. A facility attachment (FA) is prepared in cooperation with the IAEA for each facility to describe arrangements specific to that facility. The status of the regulatory documents for the Finnish material balance areas is shown in Table 1.

Fortum (MBA WL0V)

The nuclear power plant operated by Fortum Power and Heat is located on Hästholmen Island in Loviisa on the southeast coast of Finland. This first NPP was built in Finland in the 1970s to host two VVER-440 type power reactor units. These two units share common fresh and spent fuel storages. For nuclear safeguards accountancy purposes, the entire NPP is counted as one material balance area (MBA code WL0V).

Most of the fuel for the Loviisa NPP has been imported from the Soviet Union/Russian Federation. The spent fuel of the Loviisa NPP was returned to the Soviet Union/Russian Federation until 1996 and since then has been stored in the interim storage due to a change in Finnish nuclear legislation, which forbids the import and export of nuclear waste in general, including spent fuel.

As per the requirements of the Additional Protocol, the Loviisa NPP site (SSFLOV1) comprises Hästholmen Island as a whole and extends to the main gate on the mainland. Particular Safeguards Provisions for the Loviisa NPP, which define the European Commission's nuclear safeguards procedures for the facility, have been in force since 1998. The Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the Loviisa NPP.

Teollisuuden Voima (MBAs W0L1, W0L2, W0L3 and W0LS)

Teollisuuden Voima Oyj (TVO) owns and operates a nuclear power plant on the Olkiluoto Island in Eurajoki on the west coast of Finland. The Olkiluoto NPP consists of two nuclear power reactor units and an interim spent fuel storage. Olkiluoto 1 was connected to the electricity grid in 1978 and Olkiluoto 2 in 1980. There are three

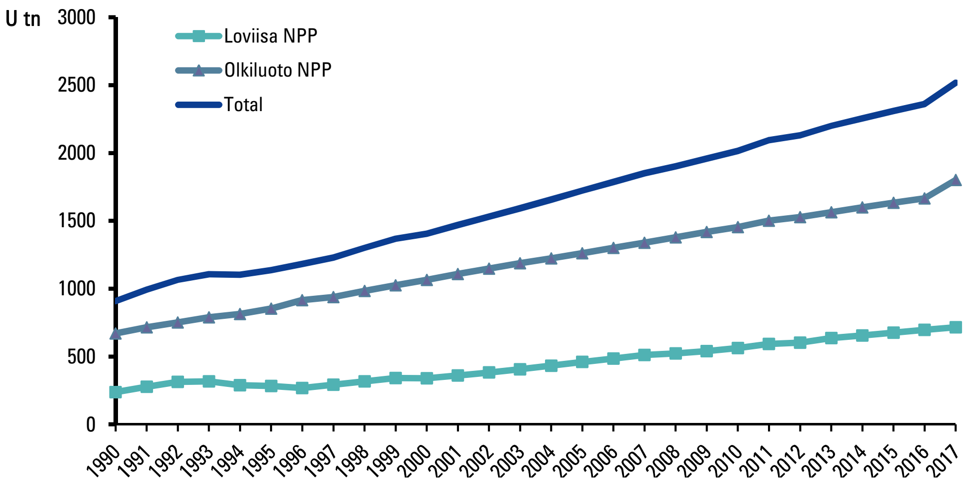


Figure 3. Uranium accumulation in Finland in 1990–2017.

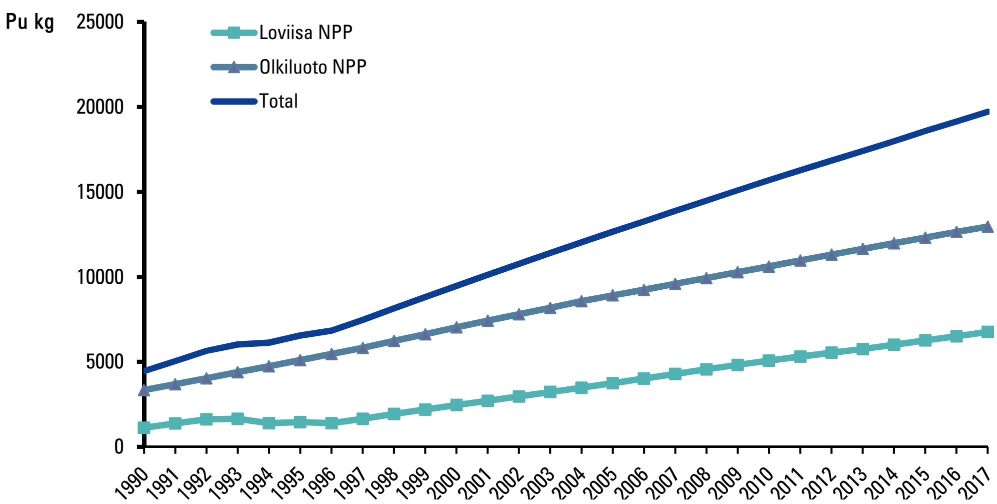


Figure 4. Plutonium in spent nuclear fuel in Finland in 1990–2017.

active material balance areas (MBA codes W0L1, W0L2, W0LS) at the Olkiluoto NPP.

Presently, the uranium in TVO's nuclear fuel is mainly of Australian, Canadian and Russian origin. This uranium is enriched in the Russian Federation or in the EU, and the fuel assemblies are manufactured in Germany and Sweden.

The Finnish Government granted a licence to construct a new nuclear reactor, Olkiluoto 3 in 2005. As a part of the licensing process, TVO's plan for arranging the necessary measures to prevent the proliferation of nuclear weapons was approved by STUK. The European Commission has assigned the MBA code W0L3 for Olkiluoto 3. TVO submitted the operating licence application to the Government in April 2016 with the aim of having the unit commissioned in 2018. The first fresh fuel for the first loading was received to OL3 in October 2017.

TVO owns most of the area of the Olkiluoto Island, but the NPP site (SSFOLK1) as per the requirements of the Additional Protocol currently comprises the fenced areas around the reactor units, the spent fuel storage and the storage for low and intermediate level waste, and the Olkiluoto 3 construction site. Particular Safeguards Provisions for the Olkiluoto NPP have been in force since 2007. The Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the Olkiluoto NPP.

Fennovoima (MBA WFV1)

Fennovoima was founded in 2007 as a new nuclear power operator in Finland. The Government approved a Decision-in-Principle in 2010 for the new operator Fennovoima to construct a new nuclear power plant at a new site. The preliminary Basic Technical Characteristics (BTC) was submitted to the European Commission in summer 2013, and the MBA code WFV1 was assigned to the future material balance area once the selection of the future Hanhikivi site at Pyhäjoki was decided. Fennovoima submitted the construction licence application to the Government in June 2015 and consequently, in September 2015, the Ministry of Employment and the Economy launched the process to evaluate the application with the desired timeline at the end of 2017. The Hanhikivi site (according to the Additional Protocol) will be declared stepwise as the project proceeds from a virgin green site to the preparatory work site and finally to the nuclear power plant. The current estimate is that the first Hanhikivi site declaration will be submitted in 2018.

VTT (MBAs WRRF and WNSC)

Small amounts of nuclear materials are located at facilities other than nuclear power plants. The most significant of those facilities is the VTT research reactor FiR1 (MBA code WRRF), located in Otaniemi, Espoo. The research reactor was the first nuclear reactor built in Finland at the Technical Research Centre of Finland (VTT). In 2012, the Ministry of Employment and the Economy and VTT announced the plan to close down the reactor and to launch the decommissioning process. The reactor was shut down and made subcritical in 2015.

Particular Safeguards Provisions that define the European Commission's nuclear safeguards procedures for the facility have been in force for VTT FiR1 from 1998. The Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the research reactor.

In contrast to this, a new building, the VTT Centre for Nuclear Safety, for experimental nuclear research is been built at the Espoo premises of VTT. The preliminary BTC for the new building was submitted to the Commission by the end of 2014 and, consequently, the MBA code WNSC was assigned to the future material balance area in 2015. In the new building, some of the experimental research that has been carried out in the building containing the research reactor is continued. STUK granted the operating licence in November 2016 for the VTT Centre for Nuclear Safety, and nuclear materials were moved to the new building in 2017. The commissioning of the new laboratories advances stepwise. Both these decisions will have long-lasting effects, due to the need for licences, permits, contracts and environmental impact assessment. This also affects safeguards, as the nuclear materials must be kept under the control of competent personnel in both material balance areas.

The VTT FiR1 site (SSFVTT1), as per the requirements of the Additional Protocol, currently consists of the whole building around the research reactor, although there are non-nuclear companies and university premises in the same building.

Major nuclear installations in Finland

Loviisa nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb1977	9 May 1977	531/507	Pressurised water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	526/502	Pressurised water reactor (PWR), Atomenergoexport

Fortum Power and Heat Oy owns the Loviisa 1 and 2 plant units located in Loviisa.

Olkiluoto nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct 1979	910/880	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	Construction licence granted 17 Feb 2005		Approx. 1,600 (net)	Pressurised water reactor (PWR), Areva NP

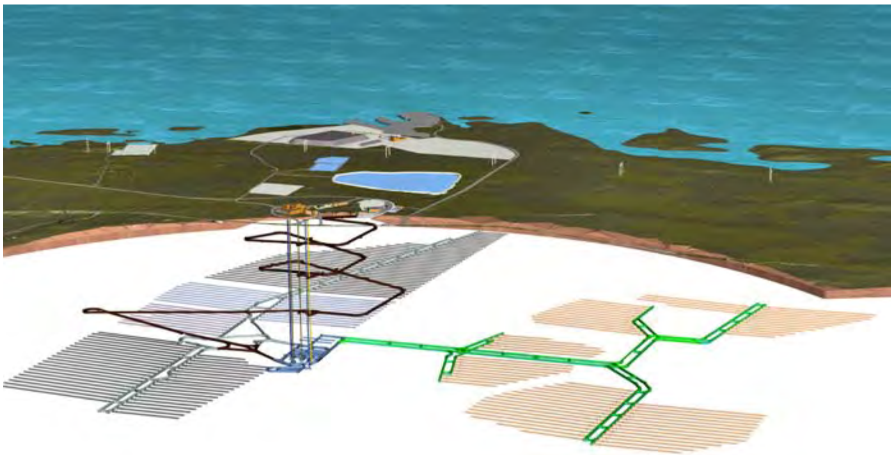
Teollisuuden Voima Oyj owns the Olkiluoto 1 and 2 plant units located in Olkiluoto, Eurajoki, and the Olkiluoto 3 plant unit under construction.

Hanhikivi nuclear facility project

Plant unit	Supplemented Decision-In-Principle approved	Nominal electric power, net (MW)	Type, supplier
Hanhikivi 1	5 Dec 2014	Approx. 1200	Pressurised Water Reactor (PWR), ROSATOM

Hanhikivi nuclear power plant FH1 is a power plant project of Fennovoima.

Olkiluoto encapsulation plant and geological repository



The planned facility under construction will consist of a surface facility for the encapsulation of spent nuclear fuel and a geological repository for disposal of the fuel in the underground at a depth of appr. 420 metres.

FiR 1 research reactor

Facility	Thermal power	In operation	Fuel	Triga fuel type
TRIGA Mark II research reactor	250 kW	March 1962–June 2015	Reactor core consists of 80 fuel rods which contain 15 kg of uranium	Uranium–zirkonium-hybrid combination: 8% uranium 91% zirkonium and 1% hydrogen

The FiR 1 research reactor, operated by VTT Technical Research Centre of Finland, was commissioned in March 1962. VTT stopped using the reactor in June 2015 and placed it in permanent shutdown.

STUK (MBA WFRS)

Small quantities of nuclear materials are stored by the Radiation and Nuclear Safety Authority (STUK), mainly materials no longer in use and hence taken into STUK's custody. STUK was founded in 1958 and has been located at its current premises in Roihupelto, Helsinki since 1994. The STUK MBA (WFRS) consists of the STUK headquarters and the "Central interim storage for small-user radioactive waste" at the Olkiluoto NPP site.

The STUK site (SSFSTUK), as per the requirements of the Additional Protocol, consists of the premises of STUK's headquarters located in Helsinki. The storage at Olkiluoto is included in the NPP's site declaration.

The University of Helsinki (MBA WHEL)

The Laboratory of Radiochemistry at the University of Helsinki (HYRL) uses small amounts of nuclear materials. HYRL is located at the Kumpula university campus in Helsinki. In 2016 and also at the end of 2017 the University's internal structure was reorganised and the current stakeholder is the Department of Chemistry.

The HYRL site (SSFHYRL), as per the requirements of the Additional Protocol, comprises the whole building housing the laboratory.

Freeport Cobalt Oy (MBA WKK0)

The by-products of Kokkola Chemicals facility's cobalt purification process contain uranium, which qualifies these by-products as nuclear material. Kokkola Chemicals has an operating licence to produce, store and handle nuclear material. In 2013, Freeport-McMoRan Copper & Gold Inc. acquired the ownership of the OM Group. The current operator is Freeport Cobalt Oy, and the facility is located at Kokkola on the west coast of Finland.

Norilsk Nickel Harjavalta Oy (MBA WNNH)

Norilsk Nickel Harjavalta Oy operates the nickel refining plant at Harjavalta in western Finland. The plant was commissioned in 1959, expanded in 1995 and again in 2002. The refinery of Norilsk Nickel Harjavalta employs the technique of the sulphuric acid leaching of nickel products. Uranium residuals are extracted from the nickel products, for example from the Talvivaara mine. In March 2010, STUK granted a licence to extract less than 10 tonnes of uranium per year. The Norilsk Nickel Harjavalta company submitted the basic technical characteristics (BTC) to the European Commission in December 2010.

Terrafame Oy (MBA WTAL)

In 2010, the Talvivaara Sotkamo Ltd mining company announced its interest in investigating the recovery of uranium as a separate product from its sulphide ore body. The Basic Technical Characteristics (BTC) were submitted to the European Commission in 2010, and the MBA code WTAL is assigned to the future uranium extraction plant that has been constructed as a separate part of the mineral processing plant. The production of uranium was expected to commence in 2013. However, Talvivaara Sotkamo Ltd filed for bankruptcy in November 2014. During 2015 a new state-owned company Terrafame took over the mining operations at Talvivaara. At the end of 2016, the use of the uranium extraction plant was again included in the mining and mineral processing planning. STUK granted licence for small-scale pilot testing of the mineral processing techniques in December 2017 but the use of the extraction plant needs the operating licence to be granted by the Government. The application was submitted to the Government at end of October 2017 and is under processing by the Ministry of Economic Affairs and Employment. The MBA code WTAL is still kept available for possible future nuclear activities.

Other nuclear material holders

There are about ten minor nuclear material holders in Finland. One of them is an actual material balance area: the University of Jyväskylä, Department of Physics (JYFL, MBA code WDPJ), but in fact the nuclear material at JYFL has been derogated and exempted by the European Commission and the IAEA. Other minor nuclear material holders are members of a Catch-All-MBA (CAM), for the purposes of international nuclear safeguards. Most of these have depleted uranium as radiation-shielding material.

Posiva (MBAs W0LE and W0LF)

Posiva Oy is the company responsible for the disposal of spent nuclear fuel in Finland. It is owned by the nuclear power plant operators TVO and Fortum. Posiva has been excavating an underground rock characterisation facility called Onkalo at Eurajoki since 2004, and thus preparing for the construction of the disposal facility. In the IAEA safeguards approaches, it has been suggested that the geological formation should be under safeguards during the whole lifetime of the underground facility. For this reason, Posiva was required to develop a non-proliferation handbook, such as a nuclear materials handbook, to describe its safeguards procedures and reporting system already before becoming a nuclear material holder. The licence to construct the disposal facility was granted by the Government in November 2015. Based on the drawings presented in the application, the preliminary BTCs were prepared for both facilities separately and submitted to the Commission in June 2013. The MBA codes assigned for the future facilities are W0LE for the encapsulation plant and W0LF for the geological repository. The installation without nuclear materials but with the two BTCs for these future Material Balance Areas constitutes a site according to the Additional Protocol. The Posiva site (SSFPOS1) covers the fenced area around the buildings supporting the construction of the facilities.

Other stakeholders

Nuclear expert organisations, technology holders and suppliers that serve nuclear and other industry are obliged to take care that non-proliferation-sensitive technology does not get into the hands of unauthorised actors and thereby contribute to nuclear proliferation. The introduction of the Additional Protocol extended the scope of safeguards to the non-proliferation control of nuclear programmes and fuel cycle-related activities. These also include research and development activities not involving nuclear materials, but are related to process or system development of fuel cycle aspects defined in the Protocol. Additionally, the United Nations Security Council Resolution 1540 requires every state to ensure that export controls, border controls, material accountancy and physical protection are efficiently addressed, and calls on all states to develop appropriate ways to work with and inform industry and the public regarding their obligations. The control of nuclear expert organisations to ensure the non-proliferation and peaceful use of sensitive technology and dual-use items is a growing global challenge for all stakeholders.

Nuclear safeguards are commonly seen as the traditional nuclear material accountancy and reporting system, the main stakeholders of which are the international, regional and local authorities and the operators. In accordance with the extended non-proliferation regime and the amendments to the Finnish legislation, the stakeholders, universities, research organisations or companies that have activities defined in the Additional Protocol are under reporting requirements and export control. These stakeholders (the Technical Research Centre and a few universities) as users of nuclear energy are required to prepare the nuclear safeguards manual and to nominate responsible persons for nuclear safeguards arrangements.

1.3 IAEA and Euratom Safeguards in Finland

The IAEA and the European Commission (Euratom safeguards) both have independent mandates to operate in Finland. These two international inspectorates have agreed on cooperation, which aims to reduce undue duplication of effort. The operators report to the Commission as required by Commission Safeguards regulation No 302/2005. It is the Commission's task to control the licence holders' accounting and reporting systems. The Commission shall draw up the particular safeguard provisions (PSP) to agree on the means of safeguards implementation taking account of the operational and technical constraints of the licence holder.

The IAEA safeguards include traditional nuclear safeguards as per INFCIRC/193, and safeguards activities in accordance with the Additional Protocol, integrated together. While this should not lead to an increase in inspections, it should enable the IAEA to assure itself of the absence of undeclared nuclear activities in a state. In practice, the number of IAEA routine interim inspections is decreasing. In contrast to this, the IAEA additionally performs 1–3 short-notice inspections per year in a state that has a number and type of nuclear installations similar to the situation in Finland. The IAEA has annually drawn conclusions confirming its confidence that all nuclear activities and materials are accounted for and are in peaceful use in Finland.

The number of IAEA and Euratom routine inspections decreased significantly in 2009, as defined in the state-level safeguards approach for Finland, which was negotiated during 2007 and 2008. At the trilateral meeting (IAEA/EC/STUK) in September 2013, it was agreed that no unannounced inspections with two hours' notice time would be performed in Finland after the beginning of 2014. Thus, currently all short notice inspections are expected to take place with 48 hours' advance notice (see infobox). STUK continues with annual routines consisting of approximately 40 field inspections, which enables the effective safeguards implementation of the international inspectorates.

According to the Finnish Nuclear Energy Act, STUK must participate when the IAEA and Euratom are having inspections at Finnish facilities, so STUK has increased preparedness for short-notice and unannounced inspections and complementary access (abbreviated SNUICA). Every weekday, one of STUK's inspectors is prepared to attend a possible IAEA of Euratom inspection.

A state's declarations on its nuclear materials and activities are the basis for state evaluation by the IAEA under the obligations of the Additional Protocol. In Finland, the state has delegated its responsibility for these declarations to STUK. STUK has been nominated as a site representative, as per European Commission regulation No 302/2005. STUK collects, inspects and reviews the relevant information and then submits the compiled declarations in timely fashion to the Commission and the IAEA.

Technical analysis methods are one tool for a state nuclear safeguards system to ensure that nuclear materials and activities within the state are in accordance with the licence holders' declarations, and that there are no undeclared activities. Such methods can provide information on the identity of the nuclear materials and confirm that licence holders' declarations are correct and complete with respect to, for example, the enrichment of uranium and the burn-up and cooling time of nuclear fuel. The technical analysis methods in use are non-destructive assay (NDA), environmental sampling and satellite imagery.

1.5 Control of uranium and thorium production

Mining and mineral processing operations aiming to produce uranium or thorium are also under regulatory control. In order to carry out these activities, a licence and accounting system to keep track of the amounts of uranium and thorium are required. A national licence is also required to export and import uranium or thorium ore and ore concentrates. These activities are also controlled by the Euratom Supply Agency and the European Commission. Mining and milling activities and the production of uranium and thorium must be reported to STUK, the Commission and the IAEA.

IAEA regular inspections:

Facilities at nuclear power plants (NPP):

- *Physical Inventory Verification (PIV)/Design Information Verification (DIV) 1/year*
- *Random Interim Inspection (RII) at 48 h notification (at least 1/year)*

Spent fuel storages at NPPs

- *PIV/DIV 1/year*
- *RII at 48 h notification (at least 1/year)*

Research reactor and locations outside facilities (LOF)

- *PIV/DIV 1/4–6 years*

New reactors, under construction

- *DIV and PIV later like at the NPPs*

Repository (Onkalo), under construction

- *PIV/DIV most likely 1 per year*

Complementary accesses at 2/24 h notification to verify declared activities or to detect undeclared activities.

1.6 Licensing and export/import control of dual-use goods

As per the Finnish Nuclear Energy Act, other nuclear fuel cycle-related activities in addition to nuclear materials are under regulatory control. A licence is required for the possession, transfer and import of non-nuclear materials, components, equipment and technology suitable for producing nuclear energy (nuclear dual-use items). The list of these other items is based on the Nuclear Suppliers' Group (NSG) Guidelines (INFCIRC/254 Part 1). The licensing authority is STUK. The Ministry for Foreign Affairs is responsible for granting NSG Government-to-Government Assurances (GTGA) when necessary. The ministry usually consults with STUK before giving the assurances. The licence holder is required to provide STUK with a list of the above-mentioned items annually. Moreover, the export, import and transfer of such items must be confirmed to STUK after the action.

Finland's export control system is based on EU Council Regulation (EC) No 428/2009 of 5 May 2009, which sets up a Community regime for the control of exports, transfer, brokering and transit of dual-use items. This regulation was amended in 2014. The export of Nuclear Suppliers' Group (NSG) Part 1 and Part 2 items is regulated by the Finnish Act on the Control of Exports of Dual-use Goods. Authorisation is required to export dual-use items outside the European Union as well as for EU internal transfers of NSG Part 1 items, excluding non-sensitive nuclear materials. The licensing authority is the Ministry for Foreign Affairs. Before granting an export licence, it also takes care of NSG Government-to-Government Assurances. The ministry asks STUK's opinion on all applications concerning NSG Part 1 items.

1.7 Control of nuclear material transport

The requirements for the transport of radioactive material are set in the Finnish regulations on the transport of dangerous goods. The requirements are based on the IAEA Safety Standard Regulations for the Safe Transport of Radioactive Material, SSR-6, and their purpose is to protect people, the environment and property from the harmful effects of radiation during the transport of radioactive material. Based on these regulations, STUK is the competent national authority for the regulatory control of the transport of radioactive material.

In addition to the dangerous goods transport regulations, the Finnish Nuclear Energy Act sets specific requirements for the transport of nuclear material and nuclear waste. Generally, a licence granted by STUK is needed for such a transport. Usually the transport licences are granted for a fixed period, typically a few years. A transport plan and a transport security plan approved by STUK are mandatory for each consignment of nuclear material or nuclear waste. A certificate of nuclear liability insurance must also be delivered to STUK before transportation. Furthermore, a package may be used for the transport of fissile nuclear material only after the package design has been validated by STUK.

1.8 Nuclear safeguards and security strengthen each other

STUK is the national authority for the regulatory control of radiation and nuclear safety, security and safeguards (3 S). All these three regimes have a common objective: the protection of people, society, the environment and future generations from the harmful effects of ionising radiation. As nuclear security aims to protect nuclear facilities' sensitive/classified information, nuclear material and other radioactive material from unlawful activities, it is clear that the majority of the activities that aim at non-proliferation of nuclear weapons, nuclear materials and sensitive nuclear technology contribute to nuclear security. Physical and information security measures at nuclear facilities and for nuclear materials including technology, sensitive information and knowledge also contribute to non-proliferation by providing deterrence, detection and delay of and response to nuclear security events. On the other hand, nuclear material accountancy and detection measures may supplement security measures through a deterrence effect.

2 Safeguards activities in 2017

2.1 The regulatory control of nuclear materials

In 2017, STUK continued with national safeguards measures and activities with 62 inspection days and 42 inspections per material balance area as in the past. The stakeholders' activities were licensed and inspected as appropriate, and inventory reports and accountancies were verified systemically. The accumulation of nuclear material at the facilities is shown in Figures 3 and 4 and the verified nuclear material inventories at the end of 2017 are shown in Tables 2 and 3 in Appendix 1. In particular in 2017, STUK safeguards inspections focused on the NDA-measurements, in particular on developing the passive gamma emission tomography (PGET). However, the total number of STUK's inspection days was relatively low in 2017 as presented in the charts in Figures 5 and 6.

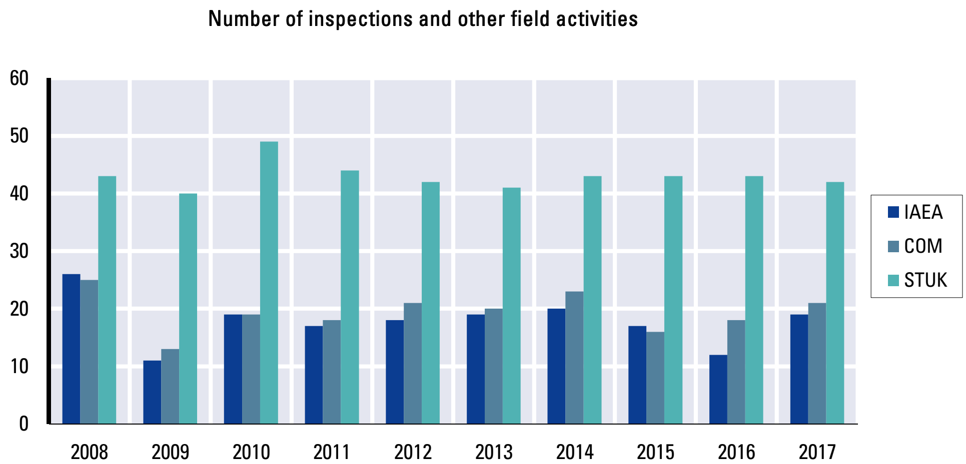


Figure 5. The number of inspections from 2008 to 2017.

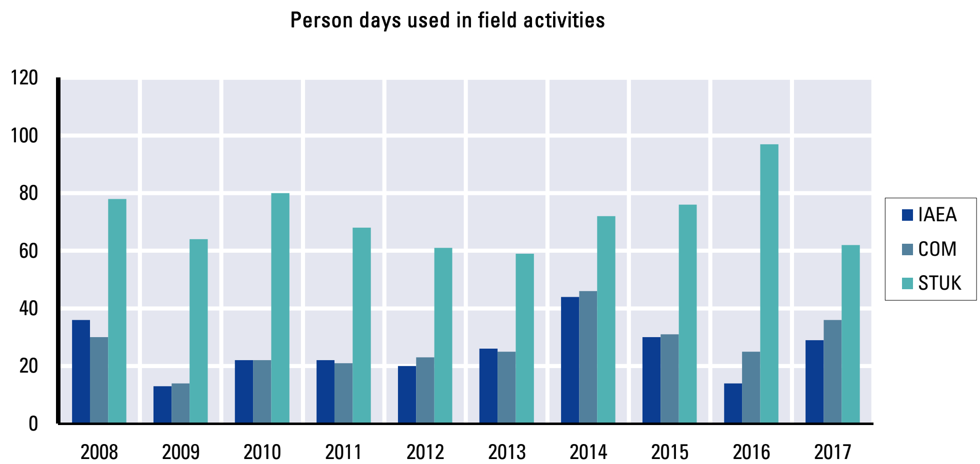


Figure 6. Inspection person days from 2008 to 2017.

The implementation of the IAEA integrated safeguards since 2008 reduces the total number of annual routine inspections days of the international inspectorates but includes short-notice random inspections. Since 2010, the number of IAEA and European Commission inspections annually has been close to 20. The recent fluctuation has been due to the different design information verification activities at the disposal site during each of the years. In 2017, there was a minimal joint survey campaign to verify the design information of the repository, which also led to small number of annual inspection days although the testing of the PGET at the NPPs required some manpower. The development of inspections and inspection person days per material balance area is presented in Figures 5 and 6. Inspections by STUK, the International Atomic Energy Agency (IAEA) and the European Commission in 2017 are presented in Appendix 2.

The implementation of safeguards in Finland was addressed at several meetings with the IAEA and the European Commission. During the IAEA General Conference in September 2017, a trilateral meeting was organised in Vienna. A trilateral meeting at least once a year is a good forum for every organisation to discuss, share information and to clarify state declarations. In addition, STUK experts met IAEA officials to discuss actual topics like implementing State Level Concept at Finnish facilities in connection with other meetings or occasions in Vienna. Similarly, in addition to the inspections STUK continued with two annual safeguards meetings with each of the NPP operator's staff members responsible for safeguards.

2.2 General safeguards activities

2.2.1 Additional Protocol Declarations

All licence holders sent their updated information about the sites for the national declaration, which is compiled by STUK, in time by 1 April. STUK submitted Finland's annual Additional Protocol declaration updates to the IAEA on 15 May 2017 as required. Additionally, STUK submitted the quarterly declarations on exports in February, May, August and November.

2.2.2 Approvals of new international inspectors

In 2017, a total of 8 IAEA and 9 Commission inspectors, newly appointed, were approved to perform inspections at nuclear facilities in Finland. Acceptance of 19 IAEA inspectors was in the process at the end of 2017.

2.2.3 Nuclear dual-use items, export licences

In 2017, the Ministry for Foreign Affairs issued 20 export licences for NSG Part 1 items, 3 for exporting nuclear technology (nuclear information) for a nuclear power plant to EU countries (Sweden, Germany, France, Great Britain) and 8 to the Russian Federation, licences to export software to Sweden (2), Italy (1), Japan (3) and the Kingdom of Saudi Arabia (1), and one for training of nuclear software to the representatives of the Kingdom of Saudi Arabia and one for training of nuclear software to the representatives of Japan.

2.2.4 Transport of nuclear materials

In 2017, fresh nuclear fuel was imported to Finland from Germany, Sweden and the Russian Federation (Appendix 1, Table A1). In relation to these imports, STUK approved five transport plans and three transport packaging designs. STUK inspected fresh nuclear fuel transports in accordance with the inspection plan, i.e. two inspections were carried out in 2017. In addition, STUK made one extra inspection to transport measures with an assistance of resident inspector.

2.2.5 International transfers of nuclear material

In 2017, TVO reported to STUK about its international fuel contracts, fuel transfers and fuel shipments. Based on the document inspection findings and audit of TVO's international nuclear material transfer accountancy and control carried out on 22 December, STUK concluded that TVO has complied with its safeguards obligations when purchasing the nuclear fuel and managing its international nuclear material transfers. The other operators purchase fuel as an end-product, and thus their accountancy does not need to cover the purchase chain abroad.

2.3 Safeguards implementation at the stakeholders

2.3.1 The Loviisa nuclear power plant

In 2017, STUK granted one licence for exporting of nuclear waste (five spent nuclear fuel rods) for research purposes to Studsvik, Sweden. STUK also granted one license for import of nuclear dual-use item.

In total, STUK performed 8 safeguards inspections at the Loviisa NPP in 2017. Safeguards DIV inspection was carried together with IAEA and the Commission on 21–22 February. The routine refuelling outage of the Loviisa 1 reactor unit took place during the period 6–27 August 2017 and the outage of the Loviisa 2 reactor unit during the period 2–19 September 2017. STUK, the IAEA and the Commission performed a Physical Inventory Taking (pre-PIT) inspection before the outages, on 26 July 2017. This inspection was carried out effectively within one working day, instead of the tradition to reserve a day and a half day at the facility for field activities. The Physical Inventory Verification (PIV) was carried out after the outage, on 26–27 September 2017. STUK identified the fuel assemblies in the reactor cores and item-counted the fuel assemblies in the loading ponds. The Loviisa 1 core was inspected on 17 August 2017 and the Loviisa 2 core on 9 September 2017. Two additional inspections, together with the IAEA and the Commission were carried out to perform activities that the international inspectors did not perform in the pre- and post PIV inspections.

On the basis of its own assessment and that of the IAEA and of the Commission inspection results, STUK concluded that Fortum's Loviisa NPP complied with its nuclear safeguards obligations in 2017.

In November, STUK performed FORK measurements at the Loviisa spent fuel pond. In total, 39 fuel elements and one dummy element were verified during the campaign.

2.3.2 The Olkiluoto nuclear power plant

In 2017 STUK granted three import licences to TVO for importing fresh nuclear fuel to the two operating units, 7 licenses to import nuclear dual-use items and one for export of nuclear waste (four spent nuclear fuel rods) for research purposes to Studsvik, Sweden. TVO updated its nuclear materials handbook with the aim of improving the import control of dual-use items. The update was approved by STUK.

STUK approved the qualification application for a new person to be appointed as the deputy safeguards responsible person for the Olkiluoto power plant.

The operating reactor units Olkiluoto 1 and 2 and the spent fuel storage of the TVO Olkiluoto power plant were subject to 17 safeguards inspections. In addition, the accountancy of the uranium batches in the TVO possession abroad was inspected. STUK performed in cooperation with the European Commission and the IAEA the inspections that comprise the physical inventory verification of the reactor units and the spent fuel storage both before and after the annual outages on 19–20 April and 12–13 July, respectively. STUK performed the core verification inspection of both reactor units before the reactor core lid was closed. In 2017, the outage was delayed so that the core verification at unit 2 took place on Sunday evening 9 July, while the already postponed physical verification and design information verification of unit 3 were scheduled for weekdays of that week. Therefore, the PIV at unit 2 was carried separately on 25 July instead of the planned June.

In addition, STUK performed a core verification inspection in connection of the unscheduled outage caused by fuel leakage in the reactor unit 1 on 24 October 2017. This outage also generated the need for an extra physical inventory verification inspection by the European Commission, the IAEA and STUK on 7 November. STUK performed further two interim safeguards inspections in the reactor units and the spent fuel storage. STUK took part in the random interim inspection initiated by the IAEA in the spent fuel storage, together with the European Commission.

In Olkiluoto 3 unit, Euratom and STUK performed inspections on 16 March and 30–31 May 2017 with the purpose of installation of surveillance equipment. The annual design information verification inspection at the Olkiluoto 3 unit was carried out by the IAEA, EC and STUK on 11 July 2017. During this inspection the functionality of surveillance equipment was verified. This verification was also required by STUK as a precondition for fresh fuel receipt. The surveillance equipment was switched on before the first consignment of fresh fuel entered in the Olkiluoto 3 unit which took place in October.

In April 2017 the IAEA, EC and STUK performed a Passive Gamma Emission Tomography (PGET) measurement campaign at the Olkiluoto NPP unit 1. The measurements also served the purpose of PGET development. During the campaign, 20 fuel objects including one rod container were measured and verified as spent fuel at pin-level.

2.3.2 The Hanhikivi nuclear power plant project

The Government granted a Decision-in-Principle in 2010 for the new operator Fennovoima to construct a new nuclear power plant at a new site. STUK initiated negotiations with the operators and the Commission as well as with the IAEA in 2011 to prepare for the implementation of safeguards in good time simultaneously with the facility development. As a consequence, the company could request the vendor organisations to facilitate safeguards implementation; for example, to improve proliferation resistance and facilitate nuclear material verification and surveillance at the future plant. In the meantime, Fennovoima created an organisation for safeguards and prepared for the implementation of safeguards.

One of the first steps in the construction process is the control of nuclear technology, such as sensitive information obtained from the bidding companies. It was obvious that the first version of the nuclear materials handbook should focus on the current needs to control the nuclear technology and dual-use equipment, so STUK approved Fennovoima's safeguards manual "Fennovoima Managements System: Nuclear Materials Manual" as early as in 2014. New version of the manual was submitted for approval in October 2017 and is under review in STUK. The preliminary design information was already submitted in 2013 and updated in 2015. Fennovoima submitted the Basic Technical Characteristics (BTC) for the first time in May 2017.

The First Safeguards by Design (SbD) meeting between Fennovoima, plant supplier, STUK, EC and IAEA was organised in Vienna on 4–5 October 2017. During the meeting Fennovoima and plant supplier presented the status, milestones and organisations of the Hanhikivi-1 Project. The international inspectorates presented their general views of safeguards. The IAEA also presented the safeguards equipment they are using for verification and surveillance. Later in the meeting the practical design features were discussed in more depth. Fennovoima and the plant supplier have provided questions in advance and these were discussed. The conclusion was that Fennovoima will provide the updated BTC to the EC as soon as the layout has been frozen. After that the next SbD meeting can be arranged. If needed, technical meetings can be arranged in between. Also, detailed questions can be made by the Fennovoima or plant supplier to the inspectorates if a need arises.

Based on the meetings on the implementation of safeguards and the control of nuclear technology with Fennovoima's staff, STUK concludes that awareness and preparedness for safeguards procedures are at an adequate level in the new organisation preparing for the new NPP project and that Fennovoima fulfilled its current safeguards obligations in 2017.

2.3.4 VTT

At the Technical Research of Finland (VTT) the preparations for licensing decommissioning of the research reactor continued. and those for the commissioning of the new building for nuclear safety research continued in 2017. The safeguards manuals for the R&D work, possession of safeguardable information, practices at the research reactor and the research building were assessed in 2016, and a few requirements and recommendations were made with a deadline in early 2017. The updated safeguards manuals were approved in March 2017 for R&D work and in April 2017 for the research reactor.

On 20 June 2017 VTT submitted an application addressed to the Government to decommission the FiR1 reactor. STUK and VTT responsible persons met regularly during the year and discussed future actions to ensure appropriate safeguards procedures. The responsible manager changed and former a deputy took over the responsibilities in 2016, and the appointment of the new deputy was approved in 2017.

VTT submitted an application for the operating licence of the Centre for Nuclear Safety in summer 2016. The licence based on the Nuclear Energy Act was granted by STUK in November 2016, and the activities started in 2017 by moving the small amounts of nuclear material used in the laboratories located in the reactor building. Both buildings having separate material balance areas (MBA) were included in the updated site declaration in 2017.

STUK and the Commission verified the nuclear material inventories of VTT's both MBAs on 8 June 2017. STUK carried out a system inspection including radiation safety and security considerations for the commissioning of the new laboratories on 22 November at VTT. The IAEA and the Commission carried out environmental sampling on 29 November in order to have a baseline before the commissioning of the hot cells installed in the research building (see Figure 7). During this inspection, the BTC was requested to be updated in early 2018 to have clarifications for the accountancy procedures.

On the basis of its assessment and inspection results, STUK concluded that VTT complied with its nuclear safeguards obligations in 2017.

Figure 7. IAEA inspector carries out environmental sampling in the clean hot cells to before their commissioning (Picture from E. Myllykylä, VTT).

2.3.5 STUK

STUK Nuclear Materials Safeguards Section verified the physical inventory, during the inspection on 26 October 2017. During this inspection STUK was required to make a re-measurement of a nuclear material item it had previously received as a domestic transfer. It can be concluded that the operating unit at STUK fulfils the requirements for national safeguards arrangements.

2.3.6 University of Helsinki

The premises of the laboratory of radiochemistry at the University of Helsinki were renovated in 2016. After the renovation work STUK carried out its safeguards inspection in December 2016 and its radiation safety inspection to the premises on 23 November 2017. In this context too, the nuclear material inventory was verified. Before that, the IAEA carried out a Complementary Access to the site on 27 April 2017. The laboratories were visited and Environmental samples taken. One of the discussion topics was the definition of "hot cells". It became obvious that the manufacturer's commercial terminology for hot cells is not corresponding to that of the IAEA's terminology. The operator was advised to use the term of shielded cells in safeguards communication.

As the operating licence expired at the end of year, the new application to renew the licence was processed at STUK and a new licence was granted for 10 years. The University structure is again reorganised, but the stakeholders name and address Department of Chemistry, University of Helsinki in English have remained.

On the basis of its assessment and inspection results and the renewal of the operating licence on 5 December 2017, STUK concluded that the University of Helsinki complied with its nuclear safeguards obligations in 2017.

2.3.7 Minor nuclear material holders

In 2017, STUK inspected the reports from the minor nuclear material holders. The minor holders were requested to prepare their nuclear materials handbooks as required in the new STUK requirements, i.e. in the Guide YVL D.1. In total, 8 handbooks prepared by the minor holders were approved in 2017.

In December 2016 STUK received a special nuclear safeguards report from the University of

Jyväskylä Department of Physics on a lost uranium sample. The special report was reviewed, and the measures taken by the operator to prevent reoccurrence of the event were introduced to the nuclear materials handbook. The inventory and practices at the University of Jyväskylä were inspected by STUK and Commission on 30 November 2017.

On the basis of its assessment, STUK concluded that the minor nuclear material holders complied with their nuclear safeguards obligations in 2017.

2.3.8 Front-end fuel cycle operators

The operators at Harjavalta and Kokkola report monthly to the Commission and STUK. The extraction of uranium from industrial purification processes is considered to be a pre-safeguard activity and therefore not subject to IAEA safeguards. In 2016, STUK and the Commission inspected the inventories and accountancy practices at both of the operators. During 2017 no new uranium extraction took place and thus no site inspections took place. The operators reported according to safeguards requirements about their planned activities and monthly inventories. On the basis of its assessment, STUK concluded that these operators complied with their nuclear safeguards obligations in 2017.

During early 2011, STUK evaluated the licence application of Talvivaara Sotkamo Ltd to begin uranium production as a by-product at the Talvivaara nickel mine. During 2011–2013, the uranium extraction plant was built as a new unit in the mineral processing complex, but the progress was halted due to economic and environmental reasons. In June 2017 the new operator Terrafame Ltd. applied for an operating licence to carry out pilot tests to analyse the processing techniques to be applied in the uranium extraction plant. The pilot tests were licensed by STUK like other minor holders possessing small amounts of natural uranium in December 2017. Thus, the nuclear safeguards manual and responsible persons for nuclear materials accountancy were approved by STUK before granting the licence. The licence application for the operation of the uranium extraction plan was submitted to the Government in October 2017. The Ministry of Economic Affairs and Employment launched the process to evaluate the application with the desired timeline in June 2018.

2.3.9 The disposal facility for spent nuclear fuel

The operator Posiva applied for the nuclear construction licence for the disposal facility in 2012. STUK assessed the application during 2013–2015 together with the Commission and the IAEA in order to clarify and facilitate safeguards measures for the permanent disposal of spent nuclear fuel. The requirement document for the IAEA/EC equipment to be installed in the encapsulation plant was prepared and finalised in 2014. This requirement document was referenced in the STUK assessment of the licence application.

In 2017 Posiva updated the BTCs both for the encapsulation plant and the geological repository. In particular, the layout of the encapsulation plant was updated in May 2017. As a consequence, the requirement document for the safeguards equipment to be installed at the encapsulation plant has to be updated by the IAEA and the Commission. The changes in the layout were discussed jointly in June at STUK. This “Safeguards-by-Design” process can be expected to continue during the progress of the facility.

Posiva updated its safeguards manual in autumn 2017 mainly to correspond to the new phase of licensed construction and new reporting practices. STUK approved the update with some minor requirements on the reporting procedures. A new deputy for the responsible person for safeguards arrangements at the disposal facility was approved by STUK in December.

The underground construction for technical servicing parts such as parking halls, personnel shafts, etc. continued during 2017, but also the construction of nuclear parts where nuclear material will be stored or transferred in the installation was launched by excavating access tunnel to the canister shaft, canister transfer tunnels, canister storage, etc. There were more than 10 active concurrent construction locations underground. At ground level, the foundation works for the encapsulation plant continued.

In 2017 STUK carried out two interim safeguards inspections at the site. The IAEA and Commission carried out design information verification on 18–20 July. On the basis of its assessment and inspection results, STUK concluded that Posiva complied with its nuclear safeguards obligations in 2017.

2.3.10 Other stakeholders

Research organisations and universities provided their annual declarations on research and development work to STUK. After its review, STUK prepared the annual declaration based on the Additional Protocol to the IAEA within the time limit of 15 May.

STUK received in December 2016, a special safeguards report from RAOS Project Oy, the Hanhikivi plant designer, on the unauthorised import of nuclear information. The report describing the measures taken by stakeholders to prevent reoccurrence of this kind of events in future was approved by STUK in 2017.

3 Development work in 2017

3.1 Development of working practices

Nuclear materials safeguards implemented by the Nuclear Materials Safeguards Section of STUK cover all typical measures of the State System of Accounting for and Control of Nuclear Materials (SSAC), and many other activities besides. Nuclear safeguards on the national level are closely linked with the other functions of nuclear materials control and non-proliferation: licensing, export control, border control, transport control, combating illicit trafficking, the physical protection of nuclear materials, and monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The continuous analysis of the developments in the involved fields of both technology and politics is a daily, multidisciplinary task in the STUK Nuclear Materials Section.

In 2017 the number of staff member in the Nuclear Material Safeguards Section was six inspectors, assistant and section head. In the end of the year the assistant retired. At the same time, the section head was nominated as the International Cooperation Manager in the Department's management. Thus, the Nuclear Materials Safeguards Sections is under reorganisation.

The renewal project of the nuclear material data base maintained at STUK (SAFKA) was finished in 2017. The database has been moved from a Microsoft Access platform to Microsoft SQL with a new web-based user interface. The work has been performed as an in-house project, utilising database and programming experts from STUK's Department of Environmental Radiation Surveillance and Emergency Preparedness. SAFKA was taken into use in spring and run in parallel with the old database for a few months. In September updating of the old database stopped and SAFKA declared the official database for Nuclear Materials at STUK. In parallel with this, the quality management system, in particular the standard operational procedures at the Reactor Regulation and Nuclear Waste and Material Regulation departments of STUK were under revision. At the Nuclear Materials Section the updates included the revision of current procedures that were included in several documents and the adoption of the new database. The issuance of these procedures was completed in 2017.

During the year STUK carried out preparatory works for the submission digital declarations using the Protocol Reporter 3 software in 2018. This was partly carried out under the support programme to the IAEA as many of internal development projects. A workshop was held in January 2017 in Helsinki together with Loviisa plant staff who prepared the test package in March. The IAEA tested and evaluated the digital declaration site maps for their compatibility in the IAEA system.

As the licensed construction of the disposal facility began in 2016, the preparatory work at the authority was focused on timely implementation of safeguards, in particular the equipment infrastructure to be fitted to the encapsulation and disposal process. The development of the passive gamma emission tomography continued in cooperation with national experts at Helsinki Institute of Physics and also within the support programme to the IAEA. A meeting between the Operator's experts and safeguards staff, STUK, Commission and the IAEA was also held in June 2017 in Helsinki at STUK's premises. In addition, the geoscientific monitoring programme was updated for its safety relevance, and its applicability to STUK safeguards was re-assessed.

3.2 Support programme to the IAEA safeguards

The Finnish Support Programme to the IAEA Safeguards (FINSP) is financed by the Ministry for Foreign Affairs and coordinated by STUK. The FINSP was established in May 1988. In 2017, FINSP was active in the areas of verification method development, development of safeguards guidance to the IAEA Member States and in inspector training.

FINSP has organised NDA training for the IAEA inspectors also in 2017. A Spent Fuel Verification Training Course was held at the Loviisa NPP on 20–23 November 2017, with the cooperation of the NPP operator Fortum.

Disposal programmes for spent nuclear fuel and the ASTOR group

The programmes for a geological repository for spent nuclear fuel in Sweden and Finland have reached the licensing phase, and the safeguards measures must be agreed on by all parties: facility designers, operators and the inspectorates. The implementation of safeguards measures has been discussed at several fora. The Experts' Group Application of Safeguards to Geological Repositories (ASTOR) held its annual meeting in the Japan on 24–27 April 2017 as a joint Support Programme task. The main aim was to finalise ASTOR report which summarises the achievements obtained during the 10-year period of the ASTOR group. Several topical groups provided the IAEA with their draft reports mainly on potential methods that can be applied to safeguard geological repositories. The report (STR-384) was published by the IAEA in August 2017.

In 2017 the main achievement of FINSP was hosting two measurements campaigns in Loviisa (VVER 440 fuel) and Olkiluoto (BWR fuel) power plants, which proved the practical usability of Passive Gamma Emission Tomographer. The prototype created in earlier task was upgraded for enhanced performance in detection time, reliability and maintainability (see Figures 8–11). The campaigns, together with one campaign held in Ringhals, Sweden (PWR fuel) proved that PGET prototype meets or exceeds all user requirements set for the method. The IAEA approved the method for safeguards use in December 2017. IAEA plans to procure new units in the coming years and FINSP is supporting IAEA in this effort.

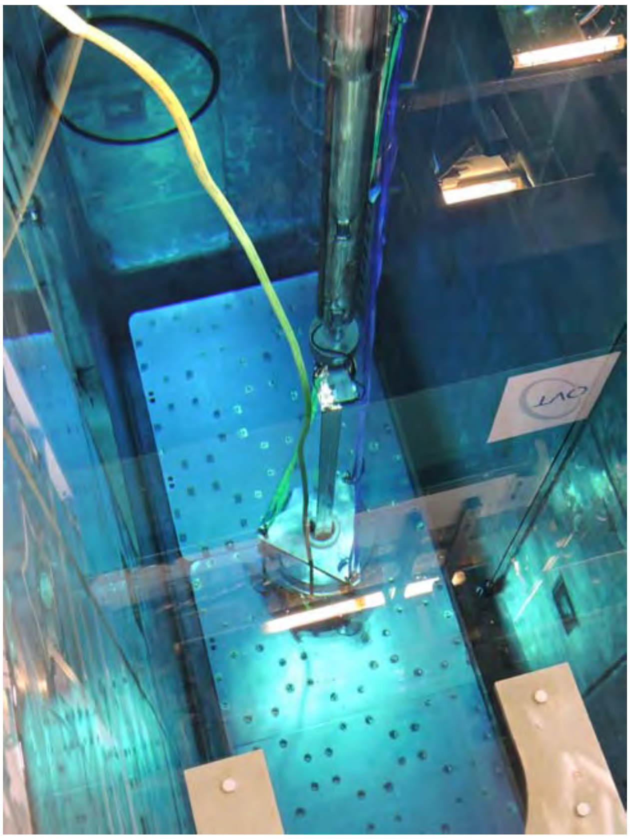


Figure 8. Passive Gamma Emission Tomographer in Olkiluoto, April 2017 (IAEA, STR 384)

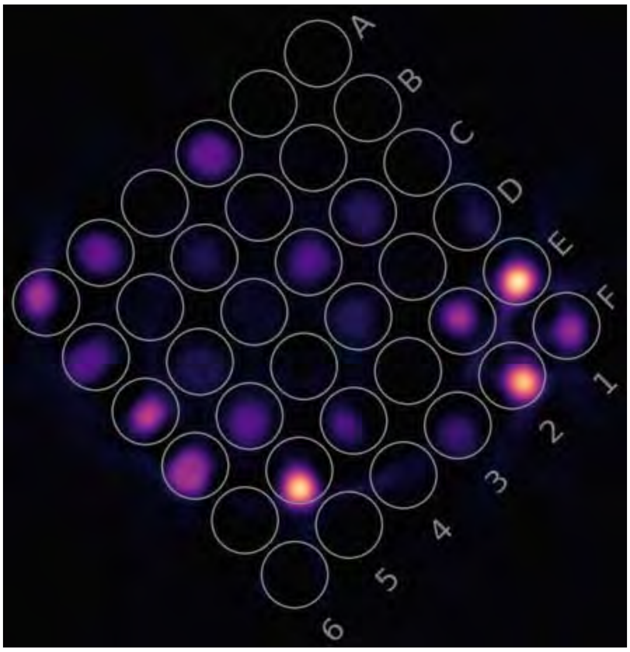


Figure 9. Passive Gamma Emission Tomography image of Olkiluoto spent fuel rod rack declared to contain 20 rods of different burn ups and cooling times. The declared data the predicted intensities coincide rather well with observed intensities. (Picture from C.Belanger-Champagne, HIP)

FINSP is also coordinating the R&D efforts in Finland made in PGET. Helsinki Institute of Physics has an active research group developing the method forward, along with the IAEA and other researchers in this field. There are several areas where improvement can be made. Additional measurements are needed to fully understand the capabilities of the method. The preparation for campaigns in Finland are being planned for 2018.

3.3 International cooperation and services

The state's regulatory authority plays an important role in implementing safeguards at a national level, and also in contributing to and participating in the international fora to share experiences and interact with other parties. Participating in international events with a suitable contribution is also the best training for safeguards inspectors. The resources are limited, so the selection of the events is important.

STUK is a member of the European Safeguards Research and Development Association (ESARDA) and has appointed Finnish experts to its committees and most of the working groups. STUK participates in the ESARDA Executive Board meetings and in several working groups. A STUK expert continued with the chairmanship of the Verification Technologies and Methodologies (VTM) Working Group. STUK expert also provided a presentation at the INMM annual meeting.

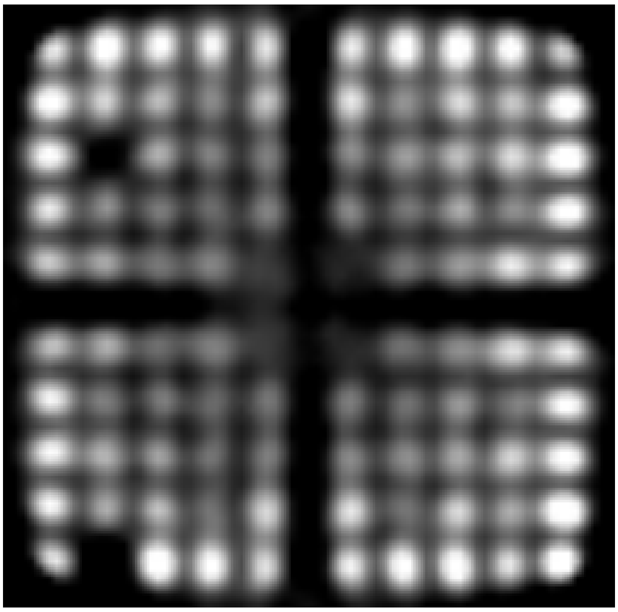


Figure 10. Tomographic image of SVEA 96 BWR fuel with two pins missing.

STUK keeps in close contact with the respective Nordic authority organisations. The development of the disposal of spent nuclear fuel in geological repositories is strengthening cooperation between Finland and Sweden. In 2017, STUK and SSM continued with bilateral annual meetings in the framework of nuclear non-proliferation. The Nordic Society's seminar on non-proliferation issues was revoked and held in Sigtuna, Sweden on 7–8 November. The topic of the year, 20 years of Additional Protocol was addressed by having Nordic reflections and presentations also from the operators. The same topic was discussed also at the ESARDA Symposium in Düsseldorf as a roundtable discussion and at the INMM meeting where the political history and process where reassessed by those persons involved in the past.

Upon request by the IAEA, STUK's experts have contributed to the IAEA's international missions. The current experience obtained from the planning, design and construction of new nuclear facilities in Finland has increased the number of requests to participate in different kinds of international cooperation.

In 2014, the partnership programme between King Abdullah City for Atomic and Renewable Energy (K.A.CARE), Kingdom of Saudi Arabia, and STUK was launched. The initiative is to give expert support to the establishment of the nuclear regulatory authority in Saudi Arabia. In the field of safeguards and nuclear security, STUK's safeguards and security experts carry out practical cooperation with their colleagues at K.A.CARE.

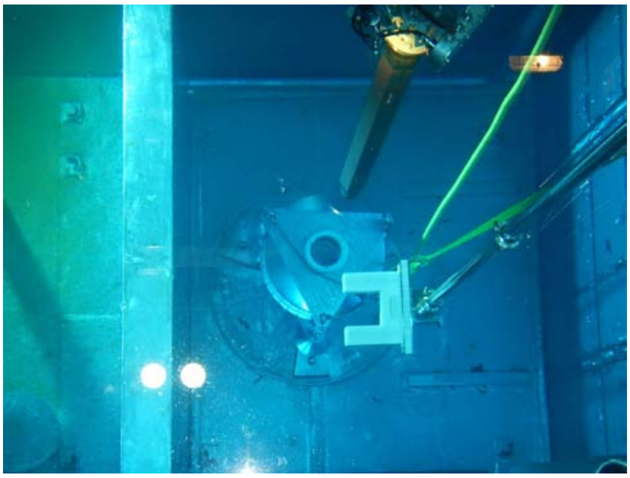


Figure 11. PGET together with FORK in Loviisa NPP, February 2017.

Table 2. Comparison of PGET and PNAR methods.

ASTOR NDA Focus Group Recommended	PGET	PNAR
Capable of pin level detection	Yes	No
Capable of verifying that the declared assembly is consistent with measured signatures	?	Yes
Capable of measuring assembly neutron multiplication	No	Yes
Capable of measuring all fuel assemblies at the measurement location and in the medium of interest (fresh water, borated water, air)	Yes	Fuel type specific hardware
Robust, low maintenance and have a low false alarm rate	?	Yes
Difficult to trick with pin substitution	System Attribute	
Measure the weight of the assembly	Load Cell Attribute	

In 2016, two EU-funded projects were launched to give support to the nuclear regulators in Vietnam and Tanzania as these countries are aiming at nuclear power and uranium mining, respectively. The kick-off meetings were held in 2016 and the cooperation is scheduled to continue for at least 2–3 years.

3.4 Final disposal and Gosser R&D project

The disposal of spent fuel requires that safety, data security and other security arrangements and the safeguards required to prevent the proliferation of nuclear weapons must be properly implemented at a national level. For this purpose, STUK launched GOSSER (Geological Disposal Safeguards and Security) to finalise the Finnish concept for safeguarding the geological disposal of spent nuclear fuel in 2016. GOSSER gathers together the necessary actions that have been done and that still need to be done to develop the cost-effective and functional safeguards concepts for the encapsulation plant and for the geological repository. The project coordinates the activities between the IAEA Safeguards Support Programme including the ASTOR group, the safeguards implementation plans of the IAEA, the European Commission and STUK, and maintains the cooperation between STUK's safety, security and safeguards sections.

GOSSER is divided in two sub-projects. The first sub-project is researching and developing NDA verification system for verification of spent fuel going to final disposal. It is commonly agreed that the fuel shall be verified in comprehensive manner and with the best available technology. PGET has for long be seen such a method, since it can detect the geometry and missing pins inside the fuel. In 2017 GOSSER actively contributed to development of PGET verifier under coordination and cooperation of Finnish support programme (FINSP) and national research programme in Helsinki Institute of Physics funded by TEKES – the Finnish Funding Agency for Innovation.

In addition, GOSSER took seriously the ASTOR recommendations that PGET alone is not sufficient method to provide the adequate information. At the present development stage PGET provides quantitative image of the fuel. It does not therefore provide full information that the declared burn-up, history and cooling time of the fuel is consistent with measured signatures. Moreover, the signal provided by PGET does not directly provide proof that nuclear material is present in the fuel. This information can be provided by a method which is capable of measuring neutron multiplication in the assembly. According to the analysis it can be seen that Passive Neutron Albedo Reactivity (PNAR) is a tool which complements the PGET nicely (Table 2).

PNAR method is using the same detectors than FORK-detector, He3 tubes for neutron detection and ionisation chambers for gross gamma detection. Ionisation chamber is present for providing the possibility to perform FORK like analysis for the fuel. It is not needed for PNAR method as such. The PNAR measurement is done in two stages, both in multiplying and in non-multiplying conditions. This can be achieved with a moving cadmium sheet. The ratio of the neutron measurements provides metrics to evaluate the multiplication in the assembly. More information is provided in STUK report by Tobin et. al. (see references).

In 2017 PNAR concept was designed and modelled. Report was electronically published in January 2018. The project is continuing and precise mechanical model of the instrument will be ready by February 2018. After that the prototype shall be built by the fall 2018. The plan is to use PNAR prototype in combination with PGET in Olkiluoto spent fuel storage in late 2018.

The other sub-project of GOSSER is to follow and analyse the work of other disciplines of the ASTOR Group's work. These include technical needs for canister identification, containment and surveillance methods to be adopted at the new type of facility, design information verification procedures, safeguards-relevant data management, etc. Although these issues are dealt with while licensing the disposal facility in Finland, the international developments are to be followed and actions taken if needed. During 2017, the safety-safeguards interface was reassessed owing to modification done in the monitoring programme at the Olkiluoto repository site by Pentti & Heikkinen 2017.

3.4 GICNT – Global Initiative to Combat Nuclear Terrorism

The Global Initiative to Combat Nuclear Terrorism, founded in 2006, is a voluntary partnership of 88 nations, 5 official observers, and co-chaired by the Russian Federation and the United States. The GICNT mission is to strengthen the global capacity to prevent, detect, and respond to nuclear terrorism by conducting multilateral activities that strengthen the plans, policies, procedures, and interoperability of partner nations. The GICNT plenary meetings are organised every two years. At these meetings, the work programme for the coming two years is agreed. The previous plenary meeting was held in Tokyo in June 2017. At this meeting, Finland was elected to take the chairmanship of the Implementation and Assessment Group (IAG) and finished chairing the Nuclear Detection Working Group (NDWG).

During 2017, the work progressed as planned. GICNT's IAG meeting was held in New Delhi, India in February. This was the primary planning meeting for the June Plenary in Tokyo. In March 2017, NDWG organised a Magic Maggiore technical reachback workshop in collaboration with the European Commission's Joint Research Centre in Ispra, Italy. In October, NDWG organised a multilateral exercise in Dushanbe, Tajikistan. During 2017 GICNT was represented in three Border Monitoring Working Group Meetings. In addition, general GICNT presentation was given in the Nordic Society Seminar on safeguards and nuclear non-proliferation issues in Sigtuna, Sweden in November.

3.5 IPNDV – International Partnership for Nuclear Disarmament Verification

International Partnership for Nuclear Disarmament Verification (IPNDV) was established on the initiative of the United States in 2014. IPNDV's first phase ended in Buenos Aires, Argentina in November 2017. During the first phase of IPNDV the work was organised under three working groups:

1) Monitoring and Verification Objectives
2) On-site Inspections
3) Technical Challenges and Solutions

Finland participated in the work of all groups. All groups completed their assignments in time. Main results of the work are made publicly available in IPNDV's www-pages (https://www.ipndv.org/). Deliverables were finalised in March and June working group meetings in Berlin, Germany and Geneva, Switzerland. End of the Buenos Aires Plenary meeting was devoted for the launching of second phase of IPNDV. Three new working groups were established. Second phase will continue until the end of 2019.

4 National Data Centre for the Comprehensive Nuclear-Test-Ban Treaty (FiNDC)

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is an important part of the international regime for the non-proliferation of nuclear weapons. The CTBT bans any nuclear test explosions in any environment. This ban is aimed at constraining the development and the qualitative improvement of nuclear weapons, including the development of advanced new types of nuclear weapons.

The CTBT was adopted by the United Nations General Assembly and was opened for signature in New York on 24 September 1996. It will enter into force after it has been ratified by the 44 states listed in its Annex 2. These 44 states participated in the 1996 session of the Conference on Disarmament and possess nuclear power or research reactors.

A global verification regime is being established in order to monitor compliance with the CTBT. The verification regime consists of the following elements: the International Monitoring System (IMS), a consultation and clarification process, on-site inspections and confidence-building measures. The IMS is almost 90% ready and is providing data from more than 300 measuring stations all over the world to more than 1,200 organisations in more than 120 countries. In addition to monitoring compliance with the treaty, the data from the IMS is used in disaster mitigation. The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is actively providing data to the global Tsunami Warning System and, since 2012, the CTBTO has been a member of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) and a co-sponsor of the Joint Radiation Emergency Management Plan of the International Organisations (JPLAN) led by the IAEA. Within this framework, the CTBTO is responsible for gathering and providing close to real-time radionuclide monitoring data to the IAEA and other participating organisations.

Comprehensive Nuclear-Test-Ban Treaty (CTBT) Status (31 December 2017)

- *CTBT Member States* 183
- *Total Ratifications* 166
- *Annex 2 Ratifications* 36

Finland signed the CTBT on its day of opening in 1996 and ratified it less than three years later. In addition to complying with the basic requirement of the CTBT of not carrying out any nuclear weapons tests, Finland actively takes part in the development of the verification regime.

In the CTBT framework, the Finnish national authority is the Ministry for Foreign Affairs. STUK has two roles: it operates the Finnish National Data Centre (FiNDC) and one of the 16 radionuclide laboratories in the IMS (RL07). The most important task of the FiNDC is to inspect data received from IMS and inform the national authority about any indications of a nuclear test explosion. The radionuclide laboratory contributes to the IMS by providing support in radionuclide analyses and in quality control of the radionuclide station network. The third major national collaborator is the Institute of Seismology at the University of Helsinki, which runs an IMS seismology station (PS17 in Lahti) and provides analysis of waveform IMS data.

4.1 International cooperation is the foundation of CTBT verification

In 2017, the Finnish National Data Centre (FiNDC) participated in meetings of the Working Group B (WGB) of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). WGB is a policy-making organ for the technical development of the verification regime. By participating in the work of WGB and its subsidiaries (workshops and expert groups), the FiNDC can provide technical expertise to the CTBTO, while also attending to Finnish national interests.

4.2 The analysis pipeline is a well-established daily routine

The FiNDC routinely analyses all radionuclide measurement data generated at the IMS radionuclide stations across the world. The analysis pipeline is linked to the LINSSI database and equipped with an automated alarm system, to enable efficient and fully automated screening of the data. The IMS network is still developing, and the number of installed air filter stations was 70 at the end of 2017 (in the final stage there will be 80).

The number of IMS stations equipped with radioxenon measurement capabilities was 31 at the end of 2017. 25 IMS radioxenon systems were certified by the CTBTO at the end of 2017. Radioxenon measurements are especially important for CTBT verification because xenon, as a noble gas, may also leak from underground tests, which seldom release particulate matter. The operational stations generated more than 1,000 gamma and beta-gamma spectra per day for the FiNDC analysis pipeline to handle. The pipeline is well-established and has been running stably for many years.

4.3 DPRK nuclear test detected in 2017

On 3 September 2017, DPRK performed an underground nuclear test at its Punggue-ri test site. The test was by far the largest so far by DPRK and reached into the 100 Megaton range, making it possible that this was a hydrogen bomb, although based on the yield estimates it can also have been a fusion boosted fission device or even a pure fission bomb. The test was registered within minutes and identified as a possible test by seismic monitoring both in Finland and at the PTS of the CTBTO. FiNDC participated in the clarification of the situation during the first hours and days after the tests and produced information bulletins to the Finnish Government based on information from the Institute of Seismology, the CTBTO and public sources. No radionuclides were detected in the IMS system that could be proven to originate from the test. However, there was a series of xenon detections in IMS stations that might be attributed to a release from the test site.

Xenon radioisotopes released from medical isotope production facilities and NPPs are regularly measured all around the globe. Anthropogenic nuclides with CTBT relevance, mainly ^{99}Tc, ^{131}I from medical isotope production and ^{137}Cs from Chernobyl and Fukushima fallout are regularly measured at some particulate stations. In 2017 the Ru-106 release that was detected in several European national networks was also detected by the CTBT IMS network.

5 Summary

STUK continued with national safeguards measures and activities with 62 inspection days and 42 inspections. Since 2010, the number of IAEA and European Commission inspections annually has been close to 20. The implementation of the IAEA integrated safeguards since 2008 in force in Finland reduces the total number of annual routine inspections days of the international inspectorates but includes short-notice random inspections. In order to be present at all of the short-notice IAEA inspections, STUK has had a daily on-call inspector.

In 2017, STUK performed 30 safeguards inspections on the material balance areas of the Finnish nuclear power plants (NPP), 9 at the Loviisa NPP and 21 at the Olkiluoto NPP. According to the IAEA state-level approach for Finland, two short-noticed random inspection were carried out, one at the Loviisa NPP and one at the Olkiluoto spent fuel storage, and one complementary access to the Helsinki University site. The IAEA collected environmental samples at the VTT Centre for Nuclear Safety before the commissioning of the hot cells designed to study radioactive materials but coming under the definitions of the Additional Protocol. STUK performed one non-destructive assay measurement campaign at both NPPs. These, in particular the passive gamma emission tomography (PGET) tests, were followed and performed by the IAEA and commission staff members raising the number of inspection days. The installation and testing of the surveillance cameras at Olkiluoto 3 unit was performed by the Commission well before the receiving of the first nuclear fuel to the new reactor. At other facilities, the Commission took part in the accountancy inspection and physical inventory verifications at the VTT Research Reactor and Centre for Nuclear Safety and at University of Jyväskylä. The total number of safeguards inspections in 2017 was 42 for STUK, 21 for the Commission, and 19 for the IAEA. The IAEA sent its safeguards statements to the Commission, which amended them with its own conclusions and forwarded them to STUK. The conclusions by the Commission were in line with the IAEA's remarks as well as with STUK's own findings; there were no outstanding questions by the IAEA or the Commission at the end of 2017.

The results of STUK's nuclear safeguards inspection activities continued to demonstrate that the Finnish licence holders take good care of their nuclear materials. There were no indications of undeclared materials or activities, and the inspected materials and activities were in accordance with the stakeholders' declarations. Neither the IAEA nor the Commission made any remarks, nor did they present any required actions based on their inspections. By means of their nuclear materials accountancy and control systems, the stakeholders enabled Finland to fulfil its own obligations under the international agreements relevant to nuclear safeguards and non-proliferation. STUK acts proactively and facilitated a meeting between the designers of the new Hanhikivi-1 unit and the IAEA staff members in Vienna in order to promote the safeguards-by-design process.

Among the major achievements in 2017 were the successful campaigns of PGET verification tool. The method is approved by the IAEA for safeguards use. The development of the method continues under FINSP and GOSSER project. The goal is to develop NDA system for final disposal of spent nuclear fuel.

In 2017, STUK's Nuclear Materials Safeguards Section cooperated closely with the IAEA in order to share experiences and train authorities' staff in countries that are aiming at nuclear programmes, i.e. uranium production or nuclear energy. This context was enlarged to Tanzania and Vietnam in EU-financed projects. The cooperation with Saudi Arabia continued in 2017.

A major goal of all current Comprehensive Nuclear-Test-Ban Treaty (CTBT)-related activities is the entry into force of the CTBT itself. To reach this goal, major steps must be taken in the political arena, and an important prerequisite for positive political action is that the verification system of the CTBTO is functioning and able to provide assurance to all parties that it is impossible to make a clandestine nuclear test without detection. The FiNDC is committed to its own role in the common endeavour so that the verification system of the CTBTO can accomplish its detection task. While still incomplete, the verification system has clearly demonstrated its ability to detect nuclear tests, as unfortunately this was done once in 2017.

6 Publications

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Okko O, Hämäläinen M, Honkamaa T, Martikka E, Moring M. Developing Safeguards Requirements and Measures for Geological Disposal of Spent Nuclear Fuel. INMM 58th Annual Meeting July 16–20, 2017, Indian Wells, California, USA.

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7 Abbreviations and acronyms

ADR
European Agreement concerning the International Carriage of Dangerous Goods by Road

AP
Additional Protocol to the Safeguards Agreement

AQG
Atomic Questions Group of the Council of the European Union

ASTOR
Application of Safeguards to Geological Repositories

BTC
Basic Technical Characteristics

CA
Complementary Access

CBRN
Chemical, biological, radiological and nuclear (such as in “protective measures taken against CBRN weapons or hazards”)

CdZnTe
Cadmium zinc telluride

CTBT
Comprehensive Nuclear-Test-Ban Treaty

CTBTO
Comprehensive Nuclear-Test-Ban Treaty Organization

DIQ
Design Information Questionnaire

DIV
Design Information Verification

DU
Depleted uranium

eFORK
enhanced FORK with a CdZnTe-gamma spectrometer (see FORK)

EPGR
Encapsulation Plant and Geological Repository

ES
Environmental Sampling

ESARDA
European Safeguards Research and Development Association

EU
European Union

FA
(1) Facility Attachment according to the Safeguards Agreement (INFCIRC/193), (2) Fuel Assembly

FiNDC
Finnish National Data Centre for the CTBT

FINSP
Finnish Support Programme to the IAEA Safeguards

FORK
Spent fuel verifier with gross gamma and neutron detection

GBUV
Gamma Burnup Verifier

GICNT
Global Initiative for Combating Nuclear Terrorism

HEU
High-enriched uranium, 20% or more of U-235

HPGe
High-Purity Germanium

IAEA
International Atomic Energy Agency

IMS
International Monitoring System (of the CTBTO)

ITU
Institute of Transuranium Elements in Karlsruhe

INFCIRC
Information Circular (IAEA document type, e.g. INFCIRC/193, Safeguards Agreement, or INFCIRC/140, the Non-Proliferation Treaty)

INMM
Institute of Nuclear Materials Management

IPNDV
International Partnership for Nuclear Disarmament Verification

IPPAS
International Physical Protection Advisory Service

IS
Integrated Safeguards

ISSAS
International SSAC Advisory Service

ITWG
International Technical Working Group for combating illicit trafficking of nuclear and other radioactive materials

JRC
The Joint Research Centre

KMP
Key Measurement Point

LEU
Low-enriched uranium, less than 20% of U-235

LINSSI
an SQL database for gamma-ray spectrometry

MBA
Material Balance Area

MEAE
Ministry of Economic Affairs and Employment

MFA
Ministry for Foreign Affairs

NDA
Non-Destructive Assay

NM
Nuclear Material

NPP
Nuclear Power Plant

NPT
The Treaty on the Non-proliferation of Nuclear Weapons (INFCIRC/140, "Non-Proliferation Treaty")

NSG
Nuclear Suppliers' Group

NRC
U.S. Nuclear Regulatory Commission

OECD/NEA
Organisation for Economic Co-operation and Development /Nuclear Energy Agency

Onkalo
Underground rock characterisation facility (for the disposal of spent nuclear fuel)

PGET
Passive Gamma Emission Tomography

PIT
Physical Inventory Taking

PIV
Physical Inventory Verification

PNAR
Passive Neutron Albedo Reactivity

PSP
Particular Safeguards Provisions

PTS
Provisional Technical Secretariat (to the Preparatory Commission of the CTBT)

Pu
Plutonium

RL07
Radionuclide Laboratory in the CTBT IMS network hosted by STUK (FIL07)

SA
Subsidiary Arrangements

SFAT
Spent Fuel Attribute Tester

SNRI
Short Notice Random Inspection

SNUICA
Short notice, unannounced inspection, complementary access, on-call inspector

SSAC
State System of Accounting for and Control of Nuclear Materials

SSM
Swedish Radiation Safety Authority

Th
Thorium

U
Uranium

UI
Unannounced Inspection

UNSC
United Nations Security Council

VTT
Technical Research Centre of Finland

WGB
Working Group B (of the CTBTO)

YVL Guide
Regulatory Guide on Nuclear Safety (STUK requirements on safety, security and safeguards, in Finnish Ydinvoimalaitosohje)

APPENDIX 1 Nuclear materials in Finland in 2017

Table A1. Summary of nuclear fuel receipts in 2017.

To	From	FA	LEU (kg)
Olkiluoto 1, WOL1	Germany	100	17 415
Olkiluoto 2, WOL2	Sweden	100	17 501
Olkiluoto 3, WOL3	Germany	196	104 698
Loviisa NPP, WLOV	Russian Federation	168	21 064

FA = fuel assembly; LEU = low-enriched uranium.

Table A2. Fuel assemblies at 31 December 2017.

MBA	FA/SFA *)	LEU (kg)	Pu (kg)
Olkiluoto 1, WOL1	1 072/500	183 005	801
Olkiluoto 2, WOL2	1 210/636	203 164	988
Olkiluoto 3, WOL3	196/0	104 698	0
Olkiluoto, spent fuel storage, WOLS	7786/7786	1 311 612	11 174
Loviisa NPP, WLOV	6147/5197	715 799	6 755

MBA = material balance area, FA = fuel assembly, SFA = spent fuel assembly

*) Fuel assemblies (FA) in core are accounted as fresh fuel assemblies
(Loviisa NPP 313 FAs and Olkiluoto NPP 500 FAs per reactor)

Table A3. Total amounts of nuclear material at 31 December 2017.

MBA	Natural U (kg)	Enriched U* (kg)	Depleted U (kg)	Plutonium (kg)	Thorium (kg)
WOL1	–	183 005	–	801	–
WOL2	–	203 164	–	988	–
WOL3	–	104 698	–	–	–
WOLS	–	1 311 612	–	11 174	–
WLOV	–	715 799	–	6 755	–
WRRF	1 508.961	57.861	0.001	< 0.001	–
WNSC	0.282	2 220	-	-	0.044
WFRS	1.842	0.537	396.3	0.010	2.370
WKKO	2 709.700	–	–	–	–
WNNH	3 588.070	–	–	–	––
WHEL	10.826	0.294	0.005	0.002	1.079
Minor holders	0.907	0.00116	1 158.6	~ 0	0.291

MBA = material balance area, WRRF = VTT Research Reactor, WFRS = STUK, WKKO = Freeport Cobalt Oy, in Kokkola, WNNH = Norilsk Nickel Harjavalta, WHEL = Laboratory of Radiochemistry at the University of Helsinki, U = uranium. *) Less than 150 g of high-enriched uranium, mainly used in detectors.

APPENDIX 2 Safeguards field activities in 2017

General information			Inspections			Inspection person days		
MBA/Location	**Date**	**Inspection type**	**IAEA**	**COM**	**STUK**	**IAEA**	**COM**	**STUK**
WLOV	21–22 February	DIV	1	1	1	2	2	2
WLOV	20–24 February	NDA measurements	1	1	1	5	5	5
WOL1, WOL2, WOLS, S SF OLK1	15 March	Interim, site check	0	0	4	0	0	8
WOL3	16 March	EC camera Installation	0	1	1	0	1	1
WLOV, S SF LOV1	20 March	Interim, site check	0	0	2	0	0	2
WOLS	27–28 March	Fuel history Cards ("NDA")	1	1	1	2	2	2
WOLF, S SF POS1	29 March	Site check	0	0	1	0	0	1
WOL2	3–4 April	NDA measurements	0	0	1	0	0	2
WLOV	11 April	Random Interim Inspection	1	1	1	1	1	1
WOL1, WOL2	19–20 April	Pre-PIT	2	2	2	2	4	2
WHEL	27 April	Complementary Access	1	0	1	2	0	1
WOL1	30 April	Core Verification	0	0	1	0	0	1
WOL3	30–31 May	C/S installation	0	1	1	0	2	2
WRRF, WNSC	8 June	PIV	2	2	2	2	2	2
WOL2	9 July	Core Verification	0	0	1	0	0	1
WOL3	11 July	DIV	1	1	1	1	1	1
WOL1, WOLS	11–12 July	PIV	2	2	2	2	2	2
WOLF	18–20 July	DIV	1	1	1	3	6	3
WOL2	25 July	PIV	1	1	1	1	1	1
WLOV	26 July	Pre-PIT	1	1	1	1	1	1
WLOV	17 August	Lo1 Core Verification	0	0	1	0	0	1
WOLS	7 September	SNRI	1	1	1	1	1	1
WLOV	9 September	Lo2 Core Verification	0	0	1	0	0	1
WLOV	26–27 September	PIV	1	1	1	2	2	2
WOL1	24 October	Core Verification	0	0	1	0	0	1
WFRS	26 October	PIV	0	0	1	0	0	3
WOL1	7 November	Interim inspection	1	1	1	1	1	1
WOLF	9 November	Interim	0	0	1	0	0	2
WNSC	22 November	3S Inspection	0	0	1	0	0	2
WHEL	23 November	3S Inspection	0	0	1	0	0	1
WNSC	29 November	Environmental Sampling	1	1	1	1	1	2
WDJP	30 November	PIV	0	1	1	0	1	1
WOL2, WOLS	13 December	Interim inspection	0	0	2	0	0	2
TVO HQ	22 December	International transfers	0	0	1	0	0	1
TOTAL			**19**	**21**	**42**	**29**	**36**	**62**

Note: At the Olkiluoto NPP, inspections are counted per MBA. MBA = material balance area, PIV = Physical Inventory Verification, CV = Core Verification, ES = Environmental Sampling, NM = nuclear material, SFAT/eFORK/GBUV = methods of non-destructive assay, RII = Random Interim Inspection.

APPENDIX 3 International agreements and national legislation relevant to nuclear safeguards in Finland

Valid legislation, treaties and agreements concerning safeguards of nuclear materials and other nuclear items in Finland (Finnish Treaty Series, FTS):

Treaties and international organisations in which Finland is a party:

Treaty on the Non-proliferation of Nuclear Weapons; adopted in London, Moscow and Washington on 1 July 1968 (1970), INFCIRC/140 (FTS 11/70).

The Treaty establishing the European Atomic Energy Community (Euratom Treaty), 25 March 1957:

- Regulation No 5, amendment of the list in Attachment VI, 22 December 1958
- Regulation No 9, article 197, point 4 of the Euratom Treaty, on determining concentrations of ores, 2 February 1960.

The Comprehensive Nuclear-Test-Ban Treaty (FTS 15/2001). This Treaty was ratified by Finland on January 15, 1999 but will not enter into force before it is ratified by all 44 states listed in Annex II of the Treaty.

International Atomic Energy Agency (since 1958).

Nuclear Energy Agency of the OECD (since 1976).

International Energy Agency (since 1992).

Safeguards Agreements based on Non-Proliferation Treaty:

The Agreement with the Kingdom of Belgium, the Kingdom of Denmark, the Federal Republic of Germany, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of Netherlands, the European Atomic Energy Community and the International Atomic Energy Agency in Implementation of Article III, (1) and (4) of the Treaty on Non-Proliferation of Nuclear Weapons (INFCIRC/193), 14 September 1973. Valid for Finland from 1 October 1995.

The Protocol Additional to the Agreement between the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Federal Republic of Germany, the Hellenic Republic, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of Netherlands, the Portuguese Republic, the Kingdom of Spain, the Kingdom of Sweden, the European Atomic Energy Community and the International Atomic Energy Agency in Implementation of Article iii, (1) and (4) of the Treaty on Non-Proliferation of Nuclear Weapons, 22 September 1998. Entered into force on 30 April 2004.

Finland is party among others to the following international conventions (the year when the convention entered into force for Finland is given in brackets):

Convention on the Physical Protection of Nuclear Material; opened for signature in Vienna and New York on 3 March 1980 (1989).

Convention on Early Notification of a Nuclear Accident; opened for signature in Vienna on 26 September 1986 (1987).

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; opened for signature in Vienna on 26 September 1986 (1990).

Convention on Third Party Liability in the Field of Nuclear Energy; adopted in Paris on 29 July 1960 (1972).

Convention Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy; adopted in Brussels on 31 January 1963 (1977).

Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material; adopted in Brussels on 17 December 1971 (1991).

The 1988 Joint Protocol Relating to the Application of the Paris Convention and the Vienna Convention; adopted in Vienna on 21 September 1988 (1995).

Convention on Nuclear Safety; opened for signature in Vienna on 20 September 1994 (1996).

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, adopted on 29 September 1997 in Vienna (2001).

Nordic Mutual Emergency Assistance Agreement in Connection with Radiation Accidents; adopted in Vienna on 17 October 1963 (1965) Agreement on common Nordic guidelines on communications concerning the siting of nuclear installations in border areas; adopted on 15 November1976 (1976).

The Agreement between Finland and Sweden on the guidelines to be followed while exporting nuclear material, technology or equipment, 4 March 1983 (FTS 20/1983).

Agreements relating to early notification of nuclear events and exchange of information on safety of nuclear facilities with Denmark (1987), Norway (1987), Sweden (1987), Germany (1993), the Russian Federation (1996) and Ukraine (1996).

Convention on Environmental Impact Assessments in a Transboundary Context (Espoo, 1991)

As of 1 January 1995, Finland has been a member of the European Atomic Energy Community (EAEC or Euratom). Consequently, the following agreements are applied in Finland:

The Agreement between the Government of Republic of Finland and the Government of Canada and Canada concerning the uses of nuclear materials, equipment, facilities and information transferred between Finland and Canada (FTS 43/76). Substituted to the appropriate extent by the Agreement with the Government of Canada and the European Atomic Energy Community (Euratom) in the peaceful Uses of Atomic Energy, 6 October 1959, as amended.

The Agreement between the Government of Republic of Finland and the Government of Australia concerning the transfer of nuclear material between Finland and Australia (FTS2/80). Substituted to the appropriate extent by the Agreement between the Government of Australia and the European Atomic Energy Community ty concerning transfer of nuclear material from Australia to the European Atomic Energy Community, 21 September 1981.

The Agreement for Cooperation with the Government of the Republic of Finland and the Government of the United States concerning Peaceful Uses of Nuclear Energy (FTS 37/92). Substituted to the appropriate extent by the Agreement for Cooperation in the Peaceful Uses of Nuclear Energy with European Atomic Energy Community and the USA, 12 April 1996.

The Agreement for Cooperation in the Peaceful Uses of Nuclear Energy Between the European Atomic Energy Community and the Government of Japan, 27 February 2006.

The Agreement Between the European Atomic Energy Community and the Cabinet of Ministers of Ukraine for Cooperation in the Peaceful Uses of Nuclear Energy, 28 April 2005.

The Agreement for Cooperation in the Peaceful Uses of Nuclear Energy Between the European Atomic Energy Community and the Government of the Republic of Kazakhstan, 4 December 2006.

Bilateral Safeguards Agreements made by Finland:

The Agreement between the Government of the Republic of Korea and the Government of the Republic of Finland for Cooperation in the Peaceful Uses of Atomic Energy, entered into force on 1.1.2015 (FTS 5/2015).

The Agreement with the Government of the Russian Federation and the Government of the Republic of Finland for Cooperation in the Peaceful Uses of Atomic Energy, entered into force on 6.4.2015 (FTS 32/2015).

The Agreement on Cooperation in the Field of Peaceful Uses of Atomic Energy Between the Government of the Kingdom of Saudi Arabia and the Government of the Republic of Finland, entered into force on 3.6.2017 (FTS 48/2017).

The Agreement with the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy (FTS 16/69). Articles I, II, III and X expired on 20 February 1999.

The Agreement with the Government of the Russian Federation (the Soviet Union signed) and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy (FTS 39/69). Articles 1, 2, 3 and 11 expired on 1.12.2004.

The Agreement between the Government of the Kingdom of Sweden and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy 580/70 (FTS 41/70). Articles 1, 2 and 3 expired on 5.9.2000.

The Agreement on implementation of the Agreement with Finland and Canada concerning the uses of nuclear materials, equipment, facilities and information transferred between Finland and Canada (FTS 43/84).